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EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, February 5th, 1895.

Dr. Hugo Müller, F.R.S., Vice-President, in the Chair.

The death of Professor Johnstrup, Corresponding Member, was announced.

Dr. A. Brezina of Vienna, Professor C. Klein of Berlin, and Professor W. C. Brögger of Christiania, were elected as Corresponding Members of the Society.

GENERAL MEETING.

Held in the Apartments of the Geological Society, February 5th, 1895.

Dr. Hugo Müller, F.R.S., Vice-President, in the Chair.

Thirteen Members were present.

The following papers were read :—

1. On simple crystalline rocks from India and Australia: by Prof. J. W. Judd, F.R.S. (Page 56.)

2. On an accurate method of determining the densities of solids: by the Earl of Berkeley, F.G.S. (Page 64.)

3. Some points in the determination of the densities of minerals: by Prof. A. H. Church, F.R.S.

Specimens were exhibited by Prof. Judd in illustration of his paper, and a pyknometer was shown by the Earl of Berkeley.

EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, April 2nd, 1895.

Prof. N. S. Maskelyne, F.R.S., President, in the Chair.

The Rev. J. M. Gordon, F.G.S., was elected a Member of the Society.

The death of Mr. P. Dudgeon, one of the Trustees of the Society, was announced.

Mr. R. H. Scott, M.A., F.R.S., Past-President of the Society, was elected to the vacant Trusteeship.

GENERAL MEETING.

Held in the Apartments of the Geological Society, April 2nd, 1895.

Prof. N. S. Maskelyne, F.R.S., President, in the Chair.

Thirteen Members and two visitors were present.

The following papers were read :—

1. Notes on Enargite, by Mr. L. J. Spencer, B.A., F.G.S. (Page 69.)

2. An instrument for cutting, grinding, and polishing accurately-orientated section-plates and prisms of mineral and other crystals : by Mr. A. E. Tutton, A.R.C.S., F.C.S.

A specimen of enargite was shown by Mr. Spencer in illustration of his paper ; and the cutting machine was exhibited in action by Mr. Tutton, an electro-motor being employed.

Specimens of lorandite and cleveite were shown by Mr. Miers, who mentioned how a communication made by him to Prof. Ramsay relative to Dr. Hillebrand's work on the latter mineral had led to the discovery of a gas giving a spectrum including the helium line.

EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, June 18th, 1895.

Dr. Hugo Müller, F.R.S., Vice-President, in the Chair.

The death of Prof. J. D. Dana, Corresponding Member of the Society, was announced.

Prof. J. Geikie, Mr. Hutchinson, Mr. Kitto, and Lieut.-General McMahon were selected for nomination to replace the four retiring Members of Council.

GENERAL MEETING.

Held in the Apartments of the Geological Society, June 18th, 1895.

Dr. Hugo Müller, F.R.S., Vice-President, in the Chair.

Twelve Members were present.

The following paper was read :—

On two new minerals, Lewisite and Zirkelite, from Brazil : by Dr. E. Hussak and Mr. G. T. Prior, M.A., F.G.S. (Page 80.)

Specimens of these minerals were exhibited in illustration of the above paper by Mr. Prior, who also referred to a new titano-antimonate of iron, of which a preliminary examination had been made.

THE MINERALOGICAL MAGAZINE

AND

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MINERALOGICAL SOCIETY.

No. 50. SEPTEMBER 1895. Vol. XI.

On the Structure-Planes of Corundum.

By Professor JOHN W. JUDD, C.B., LL.D., F.R.S., &c.

[Read April 10th, 1894.]

WHILE examining the fine series of corundums brought from Burma by Mr. C. Barrington Brown, F.G.S., and comparing them with specimens obtained from Ceylon, Southern India, the United States and other localities, I have been led to devote especial attention to the curious "parting-planes" which are sometimes found in crystals of this mineral, but which, in other cases, appear to be entirely wanting. In making these comparisons, I have had the great advantage of being able to refer to the fine collection of corundums in the British Museum (Natural History) at South Kensington, and have to gratefully acknowledge the advice and assistance which have been so freely afforded to me at all times by Mr. Fletcher and Mr. Miers.

According to the statements made in most treatises on mineralogy, corundum is a mineral with two cleavages, one parallel to the basal plane $0R$ (111), and the other to the primitive rhombohedron. In recent years,

however, this statement has been modified by some mineralogists. The Count de Bournon, indeed, in his original memoir on the mineral (*Phil. Trans.* 1802, p. 266) pointed out that corundum exhibits cleavage only in certain cases, and that the less altered the mineral is the more difficult is it to produce "cleavage fractures." In 1874 Max Bauer, as the result of his observations on the series of corundums in the Berlin collection, was led to conclude that all the partings or divisional planes of the mineral are distinct from cleavage-planes.[1]

Tschermak in 1883 refers to these division-planes as "planes of parting" (Absonderung),[2] and this course is also followed by Dana in the 6th edition of the *System of Mineralogy*.[3]

In his classical paper on corundum, published in 1802,[4] the Count de Bournon pointed out that some corundums (especially sapphires) show no appearance of possessing cleavage, but break with a fracture which is either conchoidal or splintery. Experiments which I have made with a great number of specimens confirm this observation of de Bournon, and show that, when unaltered, corundum is quite destitute of any trace of cleavage, and further that the tendency to break up along certain planes is due to incipient change, resulting either from the action of mechanical or chemical forces, or from both of these in combination. The fracture of *unaltered* corundum is, according to my experience, strikingly similar to that of quartz, and not unfrequently is beautifully conchoidal.

Let us now proceed to consider the crystallographic planes along which "parting" has been observed in corundum.

I. Specimens of corundum are continually found terminated by basal planes $0R\{111\}$, which have evidently been produced by the transverse fracture of crystals. It is noteworthy that in these cases the basal planes often exhibit a pearly lustre, markedly different from the vitreous or adamantine lustre of the proper crystal-faces. Not unfrequently, however, the lustre of this parting plane parallel to the base is sub-metallic, being sometimes accompanied by schiller-phenomena. That this breaking up of crystals is not due to cleavage is at once shown by the fact that it is usually quite impossible to produce any parallel partings, the corundum often breaking with an irregular or conchoidal fracture like quartz. It is noteworthy, also, that perfect as is this parting along

[1] *Zeitsch. d. d. geolog. Gesellsch.* Vol. XXVI. (1874), pp. 186-193.

[2] *Lehrbuch der Mineralogie.* 1st Ed. (1883), p.

[3] *System of Mineralogy*, 6th Ed. (1892), p. 211.

[4] Description of the Corundum Stone and its varieties, &c. *Phil. Trans.*, XCII. (1802), pp. 233-326.

the basal plane, it is liable to interruption, the separation often deviating from the original plane, and following another which is near to, but parallel with it. This is especially well seen when the surfaces are studied under the microscope by reflected light.

II. The remarkable separation of some specimens of corundum along the rhombohedral planes {100} is well known to all mineralogists. Tschermak calls attention to the fact that this parting parallel to the rhombohedron in corundum often shows itself strongly developed along two only of the rhombohedral faces, and not at all, or very feebly, along the third, and he interprets this as indicating a monosymmetric structure of the crystals. (*Min. und Petr. Mittheil.* Vol. I. (1878), p. 364.) Upon weathered crystals and basal sections the traces of these parting planes are often seen very conspicuously as deep striæ; and in the case of much altered corundum crystals—like those found in the Eastern United States—the crystals yield to pressure when placed in a vice, in just the same way as does calcite when subjected to the Baumhauer experiment. There appears to be a certain amount of variation in the position of these parting planes. Mügge, to whose researches on the structure-planes of minerals we are so greatly indebted, at one time thought that the deviations from the normal angles of the primitive rhombohedron were so great as to indicate a separation along the planes of a more acute rhombohedron $(-2\,R\,\{\bar{1}11\})$[1]; but his subsequent studies led him to abandon this view, though his measurements show some striking discrepancies, amounting in some cases to several degrees between the true and observed angles in these parting planes.

III. The third parting plane in corundum is less marked than the other two, and was, I believe, first noticed by von Lasaulx.[2] This parting, which is parallel to $\infty P2\,\{10\bar{1}\}$, seldom gives rise to an actual breaking up of the corundum crystals, but can be well observed in thin sections under the microscope. It has been especially noted in corundums from Ceylon, and in the variety found in the granite of the Riesengebirge. It is in the beautiful corundums exhibiting concentric growth from the Chantabun Hills in Siam, and in others said to come from Thibet, that this parting is, however, most noticeable. Certain concentric shells of these remarkable crystals are conspicuous owing to the internal reflections produced by these parting planes, while other portions in the same crystal appear to be equally or quite

[1] *Neues Jahrb. für Min.*, &c., 1884, I. 220.

[2] *Zeitschr. für Krystall.* 3. (1885), pp. 351, 353, 364.

destitute of this peculiarity. The traces of this parting appear on the basal plane, when their sections are studied with the microscope, as a series of very thin but remarkably sharp rectilinear rifts which are parallel to the sides of the hexagonal prism $\infty P2$ $\{10\bar{1}\}$.

It is the presence of these rifts, as pointed out by von Lasaulx, which gives rise to the remarkable asterism so conspicuous in certain varieties of corundum. It is certain, however, that the phenomenon of asterism is in other cases due to the presence of needles and plates of rutile[1] or other minerals intersecting at angles of 60°, and forming the so-called "sagenite-web" and similar structures. Such a "sagenite-web" may be detected in some corundums under the microscope, and is precisely similar to the structure which gives rise to the asterism in the phlogopite from Burgess County, Canada, and other localities.

That these three parting planes are not due to cleavage is perfectly clear. They are certainly altogether absent from corundum which has not undergone incipient alteration.

It may be well to remark at the outset of our inquiry concerning these three parting planes, that while II. (the parting parallel to the rhombohedron R follows a twinning plane of corundum, I. (the basal plane $0R$) is one which, though a possible twinning plane, has never been observed as such in this mineral; while III. (parallel to the hexagonal face $\infty P2$, which is a plane of symmetry), can never be a twinning plane.

IV. Corundum crystals sometimes appear to break up along planes passing through the vertical axis at right angles to the prism-faces. These are probably due to the twin combinations (trillings) described by DesCloizeaux, Mallard, Tschermak, von Lasaulx and other authors.

We will now proceed to consider the nature and origin of each of these parting planes of corundum.

I. When thin sections of corundum are studied under the microscope, a series of rifts, more or less sharp and rectilinear, can be seen lying parallel to the basal plane $0R\{111\}$. By employing high powers these rifts can be resolved into cavities having a slight thickness as compared with their area, and often assuming the form of negative crystals. The cavities are sometimes empty, at other times filled with the products of alteration—either diaspore or some hydrated silicate formed from it. It is the presence of these cavities, either empty or filled with diaspore or hydrous silicates,

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[1] Tschermak has in some cases proved the needles present in corundum to be rutile, by their tetragonal symmetry and their prism angles. *l.c.*, p. 364.

which gives rise to the pearly lustre on the $0R$ face of parting. More rarely, compounds having a metallic or submetallic lustre are developed in the cavities, and these give a metallic lustre to the cleavage face, as in varieties from Siam and Thibet. The fact that in other parts of a crystal which is thus traversed by partings along the basal plane, the ordinary conchoidal fracture may be exhibited, is evidence that the production of the cavities is a more or less local phenomenon.

It is clear, therefore, that the parting along the basal plane of corundum is of the same nature as that produced in the variety of orthoclase known as murchisonite, and in the variety of augite known as diallage. The plane $0R$ (111) is a solution plane, and parallel to this plane cavities are produced, of the nature of negative crystals, which have a great development in that plane but are of very insignificant thickness. These negative crystals sometimes appear to have the triangular form so characteristic of the natural etched figures (Verwitterungs-figuren) which are frequently exhibited on the basal plane of corundum. At other times they exhibit remarkable irregularities of form, but always show a tendency to be bounded by the rhombohedral faces.

That the basal plane is a *solution plane* of corundum is shown by the fact that the crystals from Burma and other localities which have undergone partial conversion into diaspore and hydrous silicates exhibit a remarkable step-like structure (resembling that of "Babel-quartz" on a very minute scale), showing that the chemical disintegration of the crystal has been governed by the existence of these solution planes. This fact is beautifully illustrated in the fine ruby presented to the British Museum by Mr. Ruskin, which exhibits the shaly structure due to corrosion and the natural etched figures in a very striking manner. I have no doubt that this fine ruby came from Burma, and many small specimens which I have examined from the same locality exhibit similar characters. As in the case of murchisonite and diallage, the multiplication of cavities along certain planes gives rise to a plane of weakness or a parting plane in the crystal along which it readily divides.

II. The planes parallel to $R\{100\}$ are twinning planes of corundum, and *lamellar twinning* on these planes is very common in crystals of this mineral. As has been so well shown by Mügge, there is every reason to believe that the lamellar twinning of corundum is, like that of calcite, felspar, and other minerals, of mechanical origin, and has been developed by pressure.[1] It may be, however, as suggested by von Lasaulx,[2] that

[1] *Neues Jahrb. für Min.*, 1886, I., p. 147.
[2] *Zeits. für Krystall.*, X. (1885), pp. 364-5.

the strains set up in a crystal during its gradual growth may produce alike the optical anomalies and the twin-lamellæ. But whether produced during the growth of the crystal or long subsequently, the *lamellar twinning* is certainly not an essential character, but a secondary and accidental one. The whole crystal may be destitute of any trace of lamellar structure; or the lamellæ may be developed in certain concentric shells or patches of the crystal, and be absent from others; or it may be well shown in the case of one or two of the rhombohedral planes, and almost or quite wanting in the others, as pointed out by Tschermak. Moreover, in their irregularities and flexures, as well as in the capricious mode of their development, these lamellæ exactly resemble the often curved and distorted lamellæ found in calcite, felspar and quartz.

That the planes bounding the twin lamellæ parallel to $R\{100\}$ become *solution-planes* there cannot be the smallest doubt, and crystals are sometimes found in which more than one-third of the corundum has been converted into diaspore and various hydrous silicates by chemical changes set up along these planes. Beautiful examples of sapphire thus altered were brought from Ceylon by Mr. C. Barrington Brown and by Mr. Baddeley.

The production of negative crystals and other cavities along these rhombohedral faces, and the manner of their infilling by diaspore, hydrous silicates and sometimes by material having a metallic lustre, can often be studied under the microscope.

III. Thin sections of corundum show that the rifts parallel to $\infty P2\{10\bar{1}\}$, when intersected, appear as fine lines. These under the microscope are seen to be sections of negative crystals, either empty or partially or wholly filled with decomposition products. The cavities in question are generally developed on a smaller scale than those parallel to the basal plane, but are perhaps more numerous. They are often the cause of the very distinct sheen ("schiller") which is exhibited by many varieties of corundum. When such varieties are cut *en cabochon*, with the centre of the curve opposite to the apex of the crystal, the phenomenon of asterism is exhibited. Light traversing the mass is reflected from the surfaces of these negative crystals, owing to the difference between the refractive index of the contents of these cavities and that of the mineral in which they occur. Owing to the symmetrical disposition of these enclosures parallel to the hexagonal faces, the well-known six-rayed star is produced when a strong light falls upon them. In some cases the different zones of which the corundum crystal is built up show remarkable differences in their susceptibility to alteration. In these cases we find zones exhibiting

a very striking " schiller " alternating with others which retain their perfect translucency. Nowhere do we find this better illustrated than in some of the corundums from Ceylon, of which there are fine examples in the British Museum. In many other cases, like the crystals from Siam and Thibet, we find the zoned structure of corundum crystals strikingly intensified by the development of schiller and other structures in certain of the zones, while other zones are comparatively unaffected. It is sometimes difficult, however, to determine whether the structures in different zones of the corundum crystals are of primary or of secondary origin.

IV. The rarer partings at right angles to the prism-faces, and marking the planes of composition of the trilling combinations, also appear to be due in the same way to chemical alterations taking place along these structure-planes of the complex crystal.

Taking all these facts together, we are led to conclude that corundum has at least three sets of structure-planes, but that none of these can be regarded as true *cleavage*. Two of these structure-planes, those parallel to $0R$ {111} and to $\infty P2$ {10$\bar{1}$}, are normal solution-planes; the third set of structure-planes, those parallel to R {100}, are gliding planes, which, when developed, become secondary solution-planes.

We thus see how complete is the parallelism between the phenomena of the structure-planes in corundum and those exhibited by calcite felspars, augite, hornblende, sphene and many other minerals, which have been studied from the same point of view.

On some simple Massive Minerals (Crystalline Rocks) from India and Australia.

By Professor John W. Judd, C.B., LL.D., F.R.S., &c.

[Read February 5th, 1895.]

In recent years, the respective provinces of Mineralogy and Petrography have become much more clearly defined than was formerly the case. We no longer include uncrystallised substances, like obsidian, tachylyte and coals among mineral species; and, on the other hand, we recognise the fact that many materials originally analysed and treated as homogeneous—such as lapis-lazuli, emery, and many similar materials—are really mineral aggregates or rocks, and thus come within the domain of the petrographer. This last advantage has been one of the most important of those which have resulted from the application of the microscope to the study of inorganic bodies.

There still remains, however, one class of substances which may be regarded as equally within the spheres of study of the mineralogist and the petrographer. I refer to the materials called by the former "massive varieties of a mineral," and by the old petrographers distinguished as "simple crystalline rocks." These substances are essentially composed of crystals of one species of mineral, more or less perfectly developed, such as olivine, augite, garnet, epidote, topaz, &c. It would, I think, be a great convenience if, instead of giving fanciful names from localities to these rocks, they were distinguished as olivine-rock, augite-rock, garnet-rock, &c., as was done by Macculloch and the old German petrographers.

While engaged in studying the fine series of rocks and minerals brought from Upper Burma by Mr. C. Barrington Brown, I have had my attention directed to some rocks of this class which have not hitherto been described. The circumstance that a number of my friends and former students, resident in India, were able to make inquiries and supply me with trustworthy information with respect to localities, &c., has led me to try to clear away some errors that had crept into the labelling of specimens in public collections, and to obtain new light on

the nature and mode of occurrence of very interesting materials. To Mr. T. H. Holland, F.G.S , Deputy Superintendent of the Geological Survey of India, Mr. P. Bosworth Smith, F.G.S., formerly Government Mineralogist at Madras, and Dr. J. W. Evans, F.G.S., formerly in the service of the Rajah of Junagadh, I am particularly indebted. I have also received much aid from Mr. F. R. Mallet, F.G.S., who has supplied me with valuable specimens and information, and from Mr. C. Barrington Brown, F.G.S., who has visited both Ceylon and New South Wales since his exploration of Upper Burma.

Corundum-Rock.

Corundum often occurs in the Eastern States of North America in crystals of large size, but these crystals are seldom, if ever, aggregated into a rock. Emery is a rock, but not a simple one ; for the researches of J. Lawrence Smith and Tschermak show that emery is made up of corundum (sapphire), magnetite, tourmaline and some other minerals.

In several parts of India, however, we find massive rocks made up, essentially, of corundum crystals, and these may fitly be called "corundum rocks."

The best known, and probably the largest deposit of corundum-rock which has been described, is that made known to geologists by the researches of Mr. F. R. Mallet, F.G.S., formerly Superintendent of the Geological Survey of India,[1] as being found at Pipra in South Rewah.

The rock is described by Mr. Mallet as occurring in a small hill between Pipra and Kádopání, about a mile east of the River Rehr, the rocks here striking irregularly about E.N.E. and W.S.W. The thickness of the mass could not be accurately determined owing to the quantity of *débris* lying about. Mr. Mallet, however, estimated the breadth of the outcrop, where thickest, to be 90 feet, and the mass is nearly vertical, and it was traced for about half-a-mile. The other rocks with which this great mass of corundum-rock seems to be interfoliated are as follows :—

a. White quartz-schist.

b. Hornblende-rock passing into jade.

c. White tremolitic quartz-schist (fibrous).

d. White and green jade, containing some purple corundum, "euphyllite" and schorl.

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[1] *Records of the Geological Survey of India*, Vol. V. p. 20, and Vol. VI. p. 43. Also *Manual of the Geology of India. Mineralogy*, p. 48.

e. Bed of corundum-rock, reddish, purplish, or gray, with "euphyllite," schorl and diaspore in the cracks.

f. Porphyritic gneiss with hornblende-rock.

Although no indication was found that the 90 feet of rock was not composed entirely of corundum, it may nevertheless contain some subordinate bands of other rocks.

The corundum-rock is described by Mr. Mallet as containing in its cracks larger crystals of corundum, with green mica ("euphyllite"), black tourmaline, and kyanite in radiating aggregates of a reddish colour.

The green mica was analysed by Mr. Tween, with the following result:

Silica	43·53
Alumina	43·87
Oxide of Chromium	·91
Lime	1·45
Potash	7·80
Water	4·60
	102·16

This mineral, though in composition similar to "euphyllite," may equally well be placed with the chromiferous muscovite or Fuchsite.

By the kindness of Mr. Mallet I have been able to study microscopically two varieties of this rock, and a third specimen, almost certainly from the same locality, which was preserved in the British Museum collection, has been supplied to me by Mr. Fletcher.

The rock has a beautiful purple tint, and a specific gravity varying from 3·84 to 3·88. The least dense varieties are those in which a large quantity of mica and other secondary minerals have been developed. Under the microscope it is seen to be almost made up of prismatic crystals and grains of corundum, which occasionally show the secondary parting (gliding-planes) following the primitive rhombohedron. The accessory minerals present are rutile, picotite (chrome-spinel)—of dark coffee-brown colour and isotropic—diaspore, and the green mica ("euphyllite" or "fuchsite").

The corundum is as a rule purple in colour, of a tint well known in the so-called oriental amethyst. Usually, however, the colour and pleochroism are not strong when the mineral is examined in tolerably thin sections, In one very interesting specimen, however, given to me by Mr. Mallet, a remarkable phenomenon is exhibited. There are groups of intensely coloured and highly pleochroic corundum scattered about in the midst of the pale coloured mineral. That this highly coloured material is simply

corundum is shown by the fact that the crystals with intense pleochroism have the same refraction, double-refraction and extinction as those which are nearly colourless; and cases may be found in which one part of a prism is deeply coloured and pleochroic, while the other part is almost colourless. Occasional grains of sapphire occur, in which the colour given with the ordinary ray is blue, and with the extraordinary ray pale straw-yellow. In the deep purple variety *O* is a rich purple, *E* very faint yellow. The groups of highly coloured corundum appear to be generally portions of crystalline masses which extinguish simultaneously, and the rock has thus a "micro-poicilitic" structure.

A somewhat similar case of the occurrence of an intensely coloured and highly pleochroic variety of a mineral, side by side with the ordinary type, is afforded by the variety of epidote from Glencoe, to which the name of "withamite" has been given. To all appearance the colour of this mineral must be ascribed to a manganese-compound, and the colour and pleochroism is much more striking than that of piedmontite itself. Dr. Heddle, in his analysis of withamite, however, found only 0·14 per cent. of MnO, while the piedmontite of St. Marcel contains, according to Rammelsberg, 15 per cent. of Mn_2O_3. In studying cases like these, one cannot help being reminded of the interesting researches of Senarmont, which proved that a colourless salt may be rendered intensely pleochroic by introducing into it, while crystallisation is going on, a dye stuff like logwood. It is probably the condition of oxidation, and not the quantity of the manganese compound which determines the colour and pleochroism both in Withamite and in these corundums.

Mr. Holland has, at my request, made careful inquiries as to the existence of a similar purple corundum-rock in the Salem district, and he has visited the district; but can find no evidence of any such rock having ever been detected in it. I think there can be little, if any doubt, that the rock in the British Museum, which was supposed to have come from Salem and to have formed part of the Greville collection, is really from South Rewah.

Mr. Holland has, however, furnished me with a specimen of another corundum-rock, and much valuable information concerning its mode of occurrence. It is found at Hunsúr Talúg in the Mysore State. The rock is stated by Mr. Holland, who visited the district during one of his vacations, to crop out along a line running N.N.W. and S.S.E. or N.W. and S.E., at Singanamasanhalli and Nadapanhalli, whilst water-worn fragments have been found along the same line at Hunsúr, Modur and Ramenhalli—a line about 30 miles long to the N.N.W. Still farther

N.N.W., corundum is found again at Upinangadi in the South Kanara district. Associated with the corundum-bearing band are various hornblendic rocks with an imperfect foliation N.N.W. and S.S.E. to N.W. and S.E. The most prominent of these are hornblende-felspar granulitic rocks and narrower bands of amphibolite. Although the amphibolite bands are generally parallel to the common foliation, they sometimes break across the older rocks and prove their intrusive nature by bifurcating in veins. The corundum-rock is very frequently decomposed to a fine soft product, like agalmatolite, and in this pinitic product Mr. Holland has found abundant scales of graphite (Nadapanhalli); but he has never seen graphite in fresh specimens of corundum-rock itself.

The corundum-rock of the Mysore State, of which a specimen from Hunsúr Talúg has been sent to me by Mr. Holland, presents many features which distinguish it from that of Pipra in South Rewah. It is of a gray colour, composed of crystals of much larger size than those of the Pipra rock, and has a specific gravity of 3·63. Studied in microscopic sections it is seen to be made up of grains of nearly colourless corundum, almost all of which exhibit the secondary twinning-planes parallel to the faces of the primitive rhombohedron. In very thin sections the gray colour of the mass is seen to be due to the numerous dark coloured inclusions, arranged parallel to the twinning planes and, like them, probably of secondary origin. The other minerals present in the rock are diaspore and other alteration products of corundum, and a biotite with the usual high pleochroism and absorption. The decomposition products scattered through this corundum-rock are in places stained red by hydrous ferric oxide, and in other places green by chlorites.

Massive corundum or corundum-rock has been reported to occur at other points in India, but as yet I have received no definite information or specimens to substantiate the statements.

Fibrolite-Rock.

Among the minerals which de Bournon pointed out as frequently accompanying corundum in India were the two new species which he named "indianite" (anorthite) and "fibrolite" (sillimanite). The latter mineral is now known to occur very frequently in the more acid metamorphic rocks, and to frequently accompany corundum. Among the rocks which are found with the corundum-rock of the Mysore State two very interesting kinds have been sent to me by Mr. Holland. One of these is a hornblende-olivine rock, which may be referred to the cortlandites of the late Dr. G. H. Williams and the "hornblende picrites" of many

authors. The other rock is almost wholly made up of matted prisms of fibrolite. The rock is remarkable for the different sizes of its constituent minerals; the fibrolite sometimes forming crystals 10 to 20 millimetres in length and 2 or 3 millimetres broad, while others are of microscopic dimensions. All give the usual optical characters of the mineral, its cleavage, high double-refraction, and characteristic cross-fractures. The rock is of a dark gray colour, and has a specific gravity of 3·05.

Tourmaline-(Schorl)-Rock.

Petrographers are well acquainted with many rocks in which tourmaline, and especially the variety schorl, is one of the principal constituents. Most of these rocks can be shown, like the luxullianite, so fully described before this Society by Professor Bonney, to be alteration products from granite and similar rocks.

Among the remarkable Indian rocks which have recently been brought to my notice, however, is a tourmaline- or schorl-rock, of a totally different character to any hitherto described. I am indebted to my friend Mr. P. Bosworth Smith for specimens of this remarkable rock and notes upon its mode of occurrence.

The rock has been found over a very wide area. It occurs as fragments in the Kolar gold-field in the Mysore State, and has been traced thence into the North-Arcot and Salem districts of the Madras Presidencies. The rock has not been found *in situ* in the Kolar district, but veins of quartz full of tourmaline, some of which, like one at Nandydroog mine, are 7 to 8 feet wide, cut across the gold-bearing reef of the district nearly at right angles. Mr. Bosworth Smith subsequently found the rock *in situ* at Chota Nagpur, and in pebbles at Barry's Hill in the Bengal gold-mines in Northern India.

The rock from all these districts presents tolerably uniform characters—it is of a black colour, sometimes dull in the fractured surface, and sometimes with a velvety lustre. It nearly always presents a strikingly fibrous appearance, and the specific gravity of the rock was found, as the result of many careful determinations made by Mr. Bosworth Smith, to vary between 3·02 and 3·11.

In thin sections, the rock is seen to be made up of acicular crystals, often twisted and bent, of a mineral with very marked pleochroism and high absorption. These fibres often show the cross-fractures so constantly seen in fibrolite—and it was at first thought that the mineral might be a highly coloured and abnormal variety of sillimanite—though the optical characters pointed so strongly to tourmaline.

All doubt as to the nature of the mineral has been set at rest, however, by the following analysis made for me in the chemical laboratories of the Royal College of Science under the superintendence of Mr. Chapman Jones, F.C.S., F.I.C.:—

Silica	35·94
Alumina	31·22
Ferrous Oxide	9·23[1]
Lime	1·66
Magnesia	5·53
Soda	3·96
Water	3·55
Boric Acid...	9·08[2]
	100·17

Lithium was found spectroscopically in the residue of the alkalies.

The following were tested for particularly, but no traces of them could be detected: fluorine, phosphoric acid, manganese, potassium and titanium.

Mr. Riggs, in his investigation of the chemical character of the tourmaline, was unable to find fluorine in many examples of the mineral.[3]

The microscopic characters of this rock are very interesting. The portions with dull lustre and wood-like fracture are seen to contain many prisms from 0·1 to 0·2 of a millimetre in diameter; the prisms, which are sometimes straight and at other times bent and twisted, possess all the optical characters of tourmaline—the strong absorption for the ordinary ray and the dichroism (O, blackish brown; E, bluish gray),—and they exhibit a marked parallel arrangement. Between them is a material which by higher and higher powers of the microscope is resolved into aggregations of similar prisms of minute dimensions. The portions of the rock which have a velvety or almost resinous lustre, inclining to vitreous, can only be partially resolved even by the highest powers of the microscope into crystalline individuals, but the interstitial matter does not behave like a glassy substance by being isotropic between crossed nicols. The dull and fibrous and the black velvety portions of the rock alternate with one another like the different portions of a banded lava.

[1] No attempt was made to separate the FeO from any Fe_2O_3 that might have been present.

[2] A second determination of the boric acid gave 9·11.

[3] *Am. Jour. Sci.*, Vol. XXXV. (1888), p. 35.

Among the different varieties of schorl-rock from Cornwall, Saxony, &c., I have never seen any fibrous forms in the least resembling this remarkable Indian variety.

From the neighbourhood of Bingera, in New South Wales, Mr. C. Barrington Brown has collected two very interesting rocks, each essentially composed of a single mineral. These rocks occur as dykes in a great mass of serpentine forming the south-east side of the Bingera Valley, and situated between the Bingera River and the Barricks Creek.

Green-garnet-(Grossularite?) Rock.

This is a dull-green granular rock with a specific gravity of 3·31, which under the microscope is seen to be made up of crystals of a pale-green garnet. These appear to be perfectly isotropic, and show none of the anomalous double-refraction found in some varieties of this mineral. Although many rocks have been described which consist mainly of garnets of different varieties, there is only one, so far as I know, composed mainly of green varieties of the mineral. This is a rock from Dobschau, in Hungary, which has a somewhat different colour and aspect from the rock brought from Bingera. Besides the garnets, which make up the mass of this rock, there are particles of low double-refracting materials between the grains, which are in all probability decomposition products of garnet, like the well-known "kelyphite."

This green-garnet rock of Bingera sometimes contains native gold and also chrysocolla. The rock is now being worked for the gold it contains, yielding about two ounces to the ton. The dyke, which varies in width from 4 feet to 6 inches, has been traced for more than a mile.

Picotite-Rock.

A second dyke, about 2 ft. 6 inches wide, in the mass of serpentine at Bingera is a very dense, well-crystallised black material with a specific gravity of 3·90. Under the microscope it gives the characters of a chrome-spinel, being isotropic and of a rich coffee-brown colour by transmitted light. Professor Wadsworth has pointed out the close analogies between the two spinellids, chromite and picotite, and the frequent transitions between the one mineral and the other. The density and colour of the Bingera mineral lead me to refer it to picotite rather than chromite. The only other mineral associated with the spinellid in the rock is serpentine, which occurs in small quantities.

Picotite is a frequent constituent of lherzolites and other ultrabasic rocks, but I am not aware that any rock, entirely composed of that mineral, has hitherto been described.

On an Accurate Method of determining the Densities of Solids.

By The Earl of Berkeley, F.G.S.

[Read February 5th, 1895.]

In the course of some researches on the relation between the chemical constitution and the crystalline form of substances, I found it necessary to attempt an accurate determination of the densities of crystals.

Messrs. Playfair and Joule,[1] in 1843, in the course of similar researches, determined the specific gravities of numerous salts by the use of an instrument which showed the actual volume of the solid investigated. This method was found to be subject to many errors, and they abandoned it for one which is the prototype of that ordinarily used in accurate work at present. Their second method[2] consisted in the use of a flask, stoppered by a piece of thermometer tube, which in its turn was covered by a cap, the separate pieces being carefully ground to fit. The thermometer tube was first calibrated, and the capacity of the flask then determined by observing the rise of water in the tube for different temperatures.

After the salt had been introduced into the flask, the latter was filled to a mark while in a bath whose temperature was known, and then was put away to cool before weighing. For salts soluble in water they used turpentine, the specific gravity of which had been determined by the same method.

The only differences between this method and the latest development of it are, that carbon tetrachloride is now substituted for turpentine (except at high temperatures), and that the thermometer tube is replaced by either a perforated stopper or by one ending in a fine capillary, which capillary, while the flask is in the bath, dips under some of the liquid used for the observations.

By means of this process, Mr. Tutton[3]—and I take Mr. Tutton's work

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[1] Playfair and Joule, "Relations between Atomic Vols. and S. G.," *Mem. Chem. Soc.*, Vol. II., 1843-45.

[2] Playfair and Joule, "Relations between Atomic Vols. and S. G.," *Journ. Chem. Soc.*, Vol. I., 1849.

[3] A. E. Tutton, "Crystallography of the Sulphates of Potassium, Rubidium, and Calcium," *Journ. Chem. Soc.*, July, 1894.

as a type of what accurate work can do with the method—obtained the following results :—

Relative Density at 20° C.

K_2SO_4	Rb_2SO_4	Cs_2SO_4
2·6659	3·6150	4·2411
2·6609	3·6094	4·2458
2·6660	3·6128	4·2433
2·6630	3·6132	4·2459
2·6622	3·6071	4·2432
2·6617	3·6144	4.2412
2·6631	3·6073	

Greatest diff. = ·0051 or ·19 %. ·0079 or ·21 %. ·0048 or ·11 %

The following are the two chief causes of inaccuracy in the use of this method :—

(1.) The loss of liquid through evaporation during the time elapsing between filling in the bath and weighing.

It must be remembered that the most perfect glass-surface contact will not prevent a volatile liquid such as carbon tetrachloride from evaporating. In my own pyknometer the surfaces have been most carefully ground, and I find that 20 grams of the liquid at the ordinary temperature lose ·006 gram in half-an-hour.

(2.) The error due to the differences between the real temperature of the bath, the real temperature of the filled pyknometer, and that shown by the bath thermometer. A difference of ·05° C. makes a difference of ·0013 gram in 20 grams of carbon tetrachloride, and it must be borne in mind that the error may be either a positive or a negative one—hence in comparing any two results it may be doubled—and the results may be still further vitiated by the fact that this difference, or the error due to it, is also involved in the determination of the density of the carbon tetrachloride and in the calculation for the capacity of the flask.

However, Mr. Tutton partly overcomes this by determining the density of the carbon tetrachloride anew every time he determines that of the solid—that is, the bath heats two flasks, one containing the liquid and salt, the other the liquid only. This, on the assumption that the flasks are equally heated, leaves only the error due to the discrepancy between the true bath temperature and that shown by the bath thermometer. In the following method no error due to the evaporation of the liquid is involved, indeed this evaporation is actually an essential of the method.

I obtained a pyknometer having a thermometer stopper and a capillary

(closed by a cap) at the side—there is in principle nothing new about it, and the article in a rough form is sold by all chemical apparatus manufacturers. Having tried several pyknometers of various sizes, I found the following, which was made by Dr. Geisler of Bonn, to my instructions, to be the best:—

The thermometer stopper is graduated from 10° C. to 20° C. to $\frac{1}{10}$°, and of such a length that the $\frac{1}{100}$° can be estimated, and the capacity is about 12 cc. The latter is reduced to the lowest limits compatible with accuracy, so that a smaller quantity of salt will suffice; and this is of great importance in the case of salts such as Cs_2PtCl_6, which are difficult to obtain well crystallised in large quantities. The form is cylindrical, and is preferred to the spherical because of its relatively larger surface enabling it to take up more rapidly the temperature of the balance case.

I may here mention that I am having a conical shaped pyknometer made, from which I hope to obtain some advantages in the practical manipulation of the apparatus.

The method of procedure is as follows:—

After the thermometer has been compared with a standard, the pyknometer is weighed against another one as closely similar as possible, which is used as a counterpoise throughout the observations. This is necessary for two reasons. First, to insure that the error in weight due to the deposition of moisture on the glass is negligible; secondly, to do away with the correction for the air displaced by the glass of the pyknometer. The capacity of the pyknometer at different temperatures is then determined by weighing it when filled to the mark with pure water (freed from air and CO_2), and noting the temperature of the water at the instant of weighing. As the evaporation of the water is not rapid enough to cause its level to coincide with the mark within a reasonable time, it was found necessary for this purpose to fall back upon the contraction and expansion of the liquid; and to obviate any error due to the "lag" of the thermometer, two series of weighings at different temperatures were obtained—one when the pyknometer had been filled above the mark with water slightly warmer than the balance case, and the other with it filled below the mark with water colder than the case. In the first series the weighings and temperatures were taken when the contracting water brought the level and mark into coincidence; and in the second, when the expanding water did the same. Then by rejecting all observations in which the contraction or expansion was rapid, *i.e.* all observations in which less than half-an-hour had elapsed between placing in the balance case and weighing, and by taking the means of the weighings obtained

from contracting and expanding water at about the same temperatures, it was hoped the error for "lag" could be neglected.

The results obtained are :—

12·2880 grams at 12°·03 C.
12·2861 ,, ,, 13°·03.
12·2821 ,, ,, 16° 05.

These, when corrected for the density of water at the respective temperatures, give the capacity of the pyknometer at those temperatures : —

12·2933 cc. at 12°·03.
12·2935 ,, ,, 13°·03.
12·2942 ,, ,, 16° 05.

From which the expansion of the pyknometer for intermediate temperatures can be found. Having obtained these constants, the relative density of the CCl_4 used is determined by filling the pyknometer above the mark, and waiting until the CCl_4 *evaporates* down to the mark, and then weighing and observing the temperature at the same time.

The following numbers were obtained for the weight of 12·2940 cc. of the carbon tetrachloride used :—

19·8048	grams at	11°·17 C.	19·7350	grams at	14°·07 C.
19·7956	,,	11°·59 ,,	19·7339	,,	14°·11 ,,
19·7744	,,	12°·32 ,,	19·7201	,,	14°·70 ,,
19·7713	,,	12°·84 ,,	19·7169	,,	14°·84 ,,
19·7666	,,	12°·78 ,,	19·6898	,,	15°·64 ,,
19·7548	,,	13°·21 ,,	19·6610	,,	17°·33 ,,
19·7459	,,	13°·62 ,,	19·6430	,,	18°·18 ,,
19·7408	,,	13°·84 ,,	...		

and from these a curve was drawn by the use of which the weight at intermediate temperatures could be estimated.

The density of the salt is determined in a similar manner. A known weight of the powdered crystals is placed in the pyknometer, and just covered by CCl_4, and the whole put under the receiver of an air pump, which is exhausted until no more bubbles of air come from the salt. The pyknometer is then filled above the mark with CCl_4 and weighed as before.

The following results were obtained :—

K_2PtCl_6	Cs_2PtCl_6	Rb—alum.
3·4711 at 14°·13 C.	4·1930 at 13°92 C.	1·8853 at 13°·91 C.
3·4695 ,, 15°·08 ,,	4·1926 ,, 13°·79 ,,	1·8852 ,, 14°·16 ,,
3·4698 ,, 14°·43 ,,	4·1940 ,, 13°·56 ,,	1 8849 ,, 14°·17 ,,
...	...	1·8858 ,, 13°·61 ,,
Greatest diff. 0·0016	0·0014	0·0009
Percentage diff. 0·041 %	0·033 %	0·047 %

All observations are corrected for air displaced by the liquid and the weights. Also all observations in which the level of the liquid passed the mark before half-an-hour had elapsed between placing on the balance and weighing were rejected, and so were those in which the temperature of the liquid and that of the balance case differed by more than $\frac{1}{5}^{\circ}$ C.

To avoid any error due to the film of air which adheres to the inside of the glass vessel, the pyknometer was, after careful washing with water, always rinsed out three times with pure alcohol and dried.

Each separate density given above was made on a different crop of crystals; and hence the probability is that the slight disagreements in the results obtained are not due so much to the method employed, but to different states of hydration of the salt or to slight differences in the amount of residual air adhering to the powder, or perhaps to real differences in the density of the different crops of the same crystals. Therefore the method may be considered to give the density of any given sample to an accuracy of $\frac{1}{2000}$.

May I perhaps point out to mineralogists the importance of accurate density measurements? Although minerals are, as a rule, impure, yet if several accurate determinations of the densities of different specimens of the same mineral have been obtained, and if the chemical composition of the specimens are known, then it is quite possible to calculate the density of the pure substance, and the knowledge of this constant is of the utmost importance for any theoretical dealing with crystals, the more so in that the majority of minerals cannot be produced artificially.

Enargite.

By L. J. Spencer, B.A., F.G.S.,

Assistant in the Mineral Department of the British Museum.

[Read April 2nd, 1895.]

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The following is a complete *list of the forms* of enargite; those present on the British Museum specimens are indicated by one asterisk, while new forms are indicated by two. The letters are those used by Dana (*Min.*, 6th Ed.) and Goldschmidt (*Index der Krystallformen*, I., 551, 1886).

* *a* 100. Usually large and roughly striated vertically; rarely horizontally (Coquimbo).

* *b* 010. Recorded by most authors, but on the Museum specimens very rare as a face of any size, being generally only detected by the goniometer, and then not frequently.

* *c* 001. Usually large and bright with faint, or sometimes deep, striæ parallel to the macrodiagonal; rarely parallel to the brachydiagonal (Coquimbo).

** *y* 610. Doubtful, only observed by means of the δ-eyepiece of the Fuess goniometer: (Famatina).

* *r* 310. p^3 of Rammelsberg. Bright and narrow, fairly common.

** *f* 520. Bright and narrow, on two crystals from Willis Gulch, Colorado.

* *d* 210. p^2 of Rammelsberg, *v* of Pirsson. Bright and narrow, fairly common.

x 820. Twin plane, not a recorded form; some very doubtful measurements seem to indicate its presence.

** *i* 540. Narrow: Luzon and Colorado.

* *m* 110. *g* of Dauber and Goldschmidt, *p* of Rammelsberg. Usually large, often deeply striated vertically; rarely horizontally (Coquimbo).

** *N* 230. Narrow: Silverton, Colorado, also Willis Gulch.

* *h* 120. *n* of vom Rath. Bright and narrow, common.

* *l* 130. Bright and narrow, often present.

** *t* 108. Narrow: Famatina.

** *A* 207. Narrow: Famatina and Luzon.

* λ 103. Bright and narrow, not common: Famatina and Luzon.

* *n* 102. Bright and narrow, fairly common.

** *w* 709. Narrow: Parád, Hungary.

* *k* 101. Bright, often fairly large, common.

e 403. (Dauber?). This is given by Goldschmidt as 034 instead of 304.

* μ 201. *m* of Dauber and Goldschmidt. Very narrow: Famatina.

** *u* 801. Large and bright, somewhat rounded, and striated horizontally: Famatina. This is probably the steep dome mentioned by Stelzner (*l. c.* p. 241).

** *B* 601. Doubtful, only observed with δ-eyepiece: Famatina.
E 012. *e* of Pirsson.
* *s* 011. Small and bright, not frequent.
** *K* 054. Large and rough, striated parallel to the brachydiagonal Willis Gulch.
θ 051. (Zettler).
q 115. (Zepharovich). Scattered images were observed about this position; also scattered images near the positions of (113) and (114), but very doubtful; these were only present on two Famatina crystals as rough, narrow roundings.
p 112. (Dauber).
o 111. (Dauber and Zettler).
L 132. (Dauber ?).
z 134. (Pirsson).

The following table gives the measurements establishing the new forms:—

	Measured.	Limits.	No.	Calculated from *mm* 82°0½′ and *ck* 43°42′.
a : *y* 610	8° 38′	..	..	8° 14½′
f 520	19 4½	18°56′—19° 47′	5	19 11
i 540	34 22	34 17 —34½	2	34 49
N 230	52 28	51 0 —54¼	4	52 31
e : *t* 108	6 42	6 38 — 6 46	2	6 49
A 207	14 58	..	..	15 16½
w 709	36 18	36 0½—36 25	2	36 38
u 301	71 12	70 46 —71 44	3	70 46
B 601	80 1	..	..	80 6½
K 054	45 47	..	..	46 5

Owing to the striated nature of faces in the prism zone, and of the macrodomes, few of the measurements are really good, while the reflections from the cleavage surfaces are often somewhat blurred; nevertheless, from the results obtained by the measurement of forty crystals and cleavage fragments, it would seem that the value of the prism angle (*mm*) of 82° 7′, as given by Dauber, is somewhat too high. The measurements of this angle gave the following results:—

82°0½′ mean of 26 best, from crystal faces; limits 81°17′—82°34′
82°0′ ,, ,, 11 ,, ,, cleavages; ,, 81°46′—82°16′
82°1′ ,, ,, 123, all measurements; ,, 80°32′—82°39½′
82°0′ ,, ,, 10, cleavages of "clarite"; ,, 81°10′—82°45′

Also the published measurements for this angle are all lower than that given by Dauber. Breithaupt gives 81°49¼′ as the mean of his measurements of the cleavage angle, with the remark that the error cannot be more than one minute. Rammelsberg gives 81°50′ and 82°15′; v. Pettko and v. Kobell both give 82°; Neufville 82°2′ as the mean of several cleavage angles, with a variation of 3′. The means of those given by other authors are :—

	Dauber.	v. Zepharovich.	Pirsson.	L. J. S.		
				Mean.	Limits.	No.
mm, 110 : 1$\bar{1}$0	*82° 7½′	81° 48	81° 52½′	*82° 0½′	See above.	
ck, 001 : 101	43 39	43 32	43 1	*43 42	42°55′—44°19′	14
cs, 001 : 011	*39 31	39 31	39 24½	39 42½	39 39—39 45	3

Both 43° 42′ and 39° 42½′ are good measurements, and *cs* is calculated from 43° 42′ and 82° 0½′ as 39° 43¼′, this agreeing very closely with the observed angle. These angles (*mm* and *ck*) give the parameters :—

$$a : b : c = 0{\cdot}8694 : 1 : 0{\cdot}8308.$$

Dauber's measured angles for *ck*, *cp*, *cn* and *co* are much nearer to the angles calculated from these parameters than to those calculated from his own (0·8711:1:0·8248); but his determination of *cs*, which is the mean of five angles, with variation of only 7′, and v. Zepharovich's measurement of the same angle, seem to indicate that there is not the same justification in attaching a new value to the *c* axis as to the *a* axis.

Habits.—All the crystals examined were elongated in the direction of the prism zone, and terminated at the unattached end by the bright basal plane; most of them consisted only of the forms *a*, *m* and *c*, forming a six-sided prism. The forms *a* and *m* are usually equally developed, but sometimes *a* is small or absent, or at times it is large, giving rise to tabular crystals. Other prism forms are only present as narrow faces. Domal forms, of which *k* is the most common, are comparatively rare, and are usually present as narrow faces, rarely influencing the habit of the crystals by excluding the basal plane; *k*, however, often seems to be developed as a large face on crystals from Luzon. In no case was a definite pyramid face observed.

Twinning.—The only mode of twinning which has been detected on the Museum specimens is that first described by vom Rath, in which the horizontal axes (*a* and *b*) of the different individuals cross each other at

approximately 60°, as in the twins of chalcocite, aragonite, chrysoberyl, &c. Such twins are frequent on specimens from Parád (Hungary) and Famatina (Argentina), and on "clarite" from Schapbach (Baden), but seem to be rare from other localities; only a single crystal, consisting of two individuals, having been noticed on any of the other specimens (Coquimbo). Zettler, however, mentions twins from Luzon, for which he gives the twin plane as $x(320)$ in preference to $h(120)$.[1] The twin crystals nearly always show only the c and m faces with sometimes narrow h and a planes, but apparently never any of the domes, though these are often present on the simple crystals. The basal planes of the different individuals form together one large bright plane, on which, according to vom Rath's figure, are to be seen the traces of the planes of combination. Such has, however, not been observed on the Museum specimens, and the twins examined appear rather to be of the nature of interpenetration twins. The following angles were those observed between the m faces in going round the prism zone of a twin crystal from Parád, consisting of three individuals, with very bright prism faces. The angles are calculated from mm 82° 0½′ (82° 0′ was the mean of the observed angles on this crystal); the twin planes being inclined to each other.

Measured.	Calculated twin plane x (320).	Calculated twin plane h (120).
38° 26′	38° 23½′	38° 11½′
21 31	21 48½	22 12½
37 46	37 47½	37 35½
22 19	22 24½	22 12½
37 47	37 47½	38 11½
60 25	60 12	59 48½
21 47	21 48½	22 12½
59 42½	59 36	59 48½

The magnitudes of the measured angles, as well as the order in which they occur, thus show that $x(320)$ and not $h(120)$ is the twin plane. G. vom Rath gave x as the twin plane and plane of combination, but remarked that h could be equally well taken as such (the plane of combination being perpendicular thereto), as the striated nature of the prism zone rendered it impossible to distinguish between the two by measurement. The non-existence of the twin plane x as a crystal-form is remarkable.

[1] The twin crystals from Brixlegg (Dana, *Min.*, 6th ed.) are not mentioned by v. Zepharovich.

Twinning on the m (110) plane has been mentioned, but contradicted by vom Rath. J. v. Pettko says that staurolite-like twins occur at Parád; if these resemble the staurolite twins which have the individuals crossing at approximately 60°, they would probably be the ordinary x twins of enargite. Groth mentions as doubtful, twins on a macrodome on crystals from Emma mine, Utah.

Parallel growth (?) *of Enargite and Barytes.*—On a macropinacoid face of a crystal of enargite from Famatina was a minute tabular crystal of barytes, the basal planes of the two minerals reflecting light together, and as far as could be judged by the eye the prism planes (which have about the same cleavage angle) were parallel. The a, b and c axes of the two minerals are therefore respectively parallel. This was, however, only once observed, although on some specimens there were many crystals of barytes.

THE IDENTITY OF "CLARITE" WITH ENARGITE.

A specimen in the British Museum labelled "Clarit, Schapbach, Baden, 1874," was examined, and seen to consist of radiating bushy groups of earthy, bluish covellite containing bright specks of copper pyrites; only very little of the original mineral, after which the covellite is pseudomorphous, was present; this showed bright cleavage surfaces, and had all the appearance of enargite. The specimen thus agrees with the description given by F. Sandberger (*Neues Jahrb. Min.*, 960, 1874; 382, 1875) of the mode of occurrence and alteration of "clarite."

Eight small cleavage fragments of the fresh mineral were measured on the goniometer, the images not being good, the δ-eyepiece of the Fuess instrument had to be used. Generally two or three large cleavage surfaces were present, while all round the zone were many (sometimes 8 or 9) small bright cleavages, apparently belonging to small individuals intergrown in twin position in the main crystal. These cleavages corresponded in position to the perfect m cleavage of enargite, a less perfect one being at the position of a, while b was not observed. In the following table, the calculated angles are those which exist between the m cleavages when the crystals II. and III. are twinned on the two x(320) planes of the crystal I. respectively, the angle mm being taken as 82°0½′.

	Calculated.	Measured.	Limits.	No.
$m_I\ m_{II}$	37° 47½′	37° 39′	37° 17′–38° 3′	7
,,	21 48½	21 38	20 57—22 13	10
$m_{II}\ m_{III}$	38 23½	38 28	37 47—39¼	8
,,	22 24½	22 38	22¼ —23½	9
$m\,m$	82 0½	82 0	81 10—82 45	10

The measured angles agree better with the calculated angles when x (320) is taken as the twin plane, than when h (120) is taken, and when III is twinned on I instead of on II. The measurement of these fragments thus not only shows that " clarite " is identical with enargite, but indicates that x (320) is to be taken as the twin plane in preference to h (120), a point which was left as somewhat doubtful by vom Rath.

Sandberger mentions in his paper that after much trouble he succeeded in isolating an imperfect crystal which had an end face ($0P$) steeply inclined to the prism zone, and showed a perfect cleavage ($\infty \breve{P} \infty$) and a less perfect one ($\infty \breve{P} \infty$) perpendicular to the last. This crystal was too much altered on the surface for measurement, and not even the cleavage angle could be determined on the goniometer. It is mentioned that the crystal resembles the figures given by Zepharovich for the oblique freieslebenite[1]; these figures, however, refer to rhombic diaphorite and not to freieslebenite. From the above data he concluded that the crystal was oblique, and not rhombic, as he at first thought[2]; they do not, however, appear to afford sufficient grounds for this conclusion, as the two pinacoid cleavages of a rhombic crystal would naturally show different degrees of perfection, while the end face, which is a dome in Zepharovich's figures, may be one face of the dome developed to the exclusion of the basal plane of a rhombic crystal and of the other face of the dome; such has been observed in the case of the form k (101) on crystals of enargite from Parád, Hungary. This position of the crystal would, however, not agree with the perfect m cleavage of enargite. The end face may then possibly have been one face of a pyramid (pyramidal forms seem, however, to be rare on enargite), and the cleavages may have been the m cleavage of enargite with an angle of 82°, in which case $\infty \breve{P} \infty$, $\infty \breve{P} \infty$, ∞P, $0\dot{P}$ of Sandberger would correspond to m, m, a and b, and a pyramid face respectively.

The only other points of distinction emphasised are, the dark lead-gray

[1] *Ber. Ak. Wien*, LXIII., I., 1871, Pl. II., Figs. 6 and 7.

[2] *Neues Jahrb. Min.*, 960, 1874.

colour, this is, however, called dark steel-gray in the preliminary notice (*Neues Jahrb. Min.*, 960, 1874); and the hardness of 3·5 instead of 3: the density and composition being the same as those of enargite. In the preliminary notice it is stated that copper, antimony, arsenic and sulphur were detected qualitatively, with the remark that such a combination of elements is only known in fahlerz; such, however, is not the case, nor was it in 1874. It was apparently on these grounds that the name was in the first instance given, as the mineral was then said to be apparently rhombic.

Several other minerals, with a composition similar to that of enargite, have at one time and another been described. Of these, guayacanite and garbyite are mere synonyms of enargite, the names having been withdrawn by their authors. *Luzonite*,[1] however, from its absence of cleavage and its reddish colour, seems to differ from enargite, though its chemical composition and density are the same. The first mention of this mineral was made by Zerrenner[2] ("brauner Kies"); and it was stated by F. W. Fritzsche,[3] who made a qualitative analysis of it, to be massive dufrenoysite (binnite of Des Cloizeaux). Two[4] of the three analyses that have been made of *binnite* agree with the enargite formula, though the earliest,[5] which is the one usually accepted, does not. The mineral also shows an absence of cleavage, and has a brownish colour on the fractured surfaces. Moreover, as it has the same density as luzonite, these two minerals may possibly be identical, luzonite being the massive form of binnite.

A. D'Achiardi's *regnolite*,[6] which was first described as occurring in isometric tetrahedra resembling sandbergerite, and having a composition somewhat similar to enargite, may possibly be referred to binnite, though the composition is not in close agreement.

The isodimorphous series as given by F. Klockmann[7] would then become:—

Cu_3AsS_4, Enargite, rhombic	Binnite (and Luzonite), cubic.
Cu_3SbS_4, unknown	Famatinite do. (?).

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[1] A. Weisbach, *Min. Mitth.*, 257, 1874.
Berg-Hütt. Ztg., 106, 1869.

[2] *Berg-Hütt. Ztg.*, 438, 1869.

[4] Stocker-Escher, *Kenngott's Uebers.* 1856-7, 174, 1859; R. W. E. Macivor, *Chem. News*, XXX., 103, 1874.

[5] Uhrlaub, *Pogg. Ann.*, XCIV., 115, 1855.

[6] *Il Nuovo Cimento*, 314, 1870; *I Metalli*, I., 293, 294, 1883.
Zeits. Kryst., XIX., 274, 891; cf. Abst., *Min. Mag.*, X., 337, 1894.

Enargite usually contains no, or only one or two per cent. of antimony, but the three published analyses with six per cent. (Root, Domeyko, and E. Bittsanszky quoted by v. Pettko) show a transition of enargite towards the unknown member of the series, while the famatinite analysed by Frenzel[1] is half way between binnite and famatinite.

Frenzel's *lautite* has been considered by Weisbach to be a mechanical mixture of native arsenic with a sulpho-salt near enargite. It is therefore placed by Dana[2] under enargite, though it is not placed in such a position by Groth.[3] The specimens from Lauta, Marienberg, Saxony, were examined, and on the bright cleavage surfaces could be seen no trace of the native arsenic mentioned by Weisbach, the substance having all the appearance of a definite mineral. One perfect cleavage is present giving rise to a platy separation of the mineral. There are also two or more other less perfect cleavages, which give scattered images, and on the goniometer no consistent measurements could be obtained; but none of the angles, on the several fragments measured, agreed with those of enargite.

Localities of Enargite.—A complete list not having been before compiled, the following may be of use:—

Saxony.—Junge hohe Birke mine, Freiberg? (Breithaupt, *Pogg. Ann.*, LXXX., 386, 1850; not confirmed).

Baden.—Clara mine, Schapbach ("Clarite").

Silesia.—Kupferberg? (H. Fiedler, *Min. Schlesiens*, 1863).

Tyrol.—Matzenköpfl, Brixlegg.

Hungary (Matra Mts.).—Gabe Gottes mine and Katharina mine, near Parád; Recsk.

Philippine Islands.—Mancayan, District Lepanto, Luzon.

Colorado.- Gilpin Co.—Mines near Black Hawk (Willis Gulch) and Central City; Russel Gulch, particularly Power's mine.

Rio Grande Co.—Ida mine, Summit District.

San Juan Co.—National Belle mine, Red Mtn.; Silverton (from a label in the British Museum).

Park Co.—Missouri mine.

Utah.—Juab Co. (Tintic District)—Copperopolis mine (American Eagle mine) and Mammoth mine.

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[1] *Neues Jahrb. Min.*, 679, 1875.

[2] *Min.*, 6th Ed.
Tab. Uebers. Min., 3rd ed.

Millard Co.—Shoebridge mine; Dragon mine.

Salt Lake Co.—Emma mine; Oxford and Geneva mine.

Montana.—Silver Bow Co.—Several mines near Butte (Liquidator, Gagnon, Parrot, Colusa).

Lewis and Clarke Co.—Marysville (*Min. Mag.* VI., 124).

Missoula Co.—Bell and Stow mine.

South Carolina.—Chesterfield Co.—Brewer's mine.

California.—Alpine Co.—Morning Star mine; Stella mine.

Mexico.—Milpillas, Chihuahua [on A. del Castillo's mining map of Mexico this is Minillas].

Peru.—Prov. Junin: Morococha, Tarma (San Francisco mine and mine of Señor de la Carcel); Cerro-de-Pasco.

Cajamarca: Comotera mine, Cajabamba.

Chili.—Prov. Coquimbo: Hediondas mine, Elqui (this, according to Domeyko, is the locality for Field's "guayacanite"; it is not far from the smelting works after which the name is given).

Santiago: San-Pedro-Nolasco mines.

Atacama: Cerro Blanco mines.

Mine de la Ung (from a label in the British Museum).

Columbia, S. A.—Mines of Santa Anna.

Argentina.—Prov. La Rioja: Several mines in the Sierra Mejicana, Sierra Famatina (*e.g.* Upulungos, Mejicana, Verdiona, Anduesa, San Pedro Alcántara, Compañia, Coquimbana, &c.).

Catamarca: Capillitas.

San Juan: Guachi.

New South Wales.—(A. Liversidge, Minerals of N. S. Wales, 62, 1888; Catalogue of Minerals in the Australian Museum, Sydney, 1885).

Lewisite and Zirkelite, two new Brazilian Minerals.

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AND

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[Read June 18th, 1895.]

I. Lewisite.

THIS new antimonate was found in the cinnabar mine of Tripuhy, near Ouro Preto, Minas Geraes, Brazil.

The occurrence of cinnabar at this locality has been known since 1810, and a short notice of it is given by Eschwege in his *Pluto Brasilensis*, p. 456, which was published in 1833.

Some three years ago work of a prospecting character was undertaken by the Companhia Mineralogica under the direction of the mining engineer, F. P. de Oliverra, and, by his invitation, one of us had an opportunity of examining the locality and making a collection of its minerals. The cinnabar, which had previously only been known to occur in rolled fragments up to the size of a pea, was found in small quartz veins, in a metamorphic mica-schist.

The small hill, to which the cinnabar is confined, consists of argillaceous mica-schist passing into hæmatite-mica-schist (itabirite): in places the rock contains much iron-pyrites altered to limonite, and is cut by a dyke a few metres wide of diabase-porphyrite. The slope of the hill is covered with a thick bed of gravel containing numerous fragments of cinnabar up to the size of a fist. This gravel, on washing with the batea, affords a residue of fine heavy sand consisting mainly of cinnabar and specular iron, but containing also a variety of other interesting minerals.

Lewisite is one of the minerals found in this heavy sand.

Physical Characters.

The mineral is cubic, and occurs in small (seldom exceeding a millimetre in greatest diameter) perfect octahedra without modification. A measurement of the octahedral angle gave 109° 22′. Twinning according to (111) is rare. The mineral is isotropic, and has a fairly perfect octahedral cleavage.

Colour, honey-yellow to colophony brown; streak, light yellowish-brown; translucent; lustre, vitreous to resinous.

Hardness, 5·5; not brittle.

Density (weight of 1 cc.), 4·950 at 18° C., as determined on 0·9784 gr.

Under the microscope some of the crystals were seen to be filled with small, colourless, doubly-refracting grains and scales of mica, extending in part beyond the crystal faces, and also with exceedingly fine yellow needles (rutile?) and isolated gas pores.

Occasionally the crystals show a thin, sulphur yellow, pulverulent decomposition crust, and the same alteration product may be seen on the cleavage surfaces and in cavities in the centre of the crystals.

Chemical Characters.

In the Bunsen flame the mineral fuses somewhat readily on the edges, and gives a greenish-blue colour to the flame. The microcosmic bead in the reducing flame is yellow while hot, violet when cold. The mineral is insoluble in acids, is decomposed by fusion with sodium carbonate, and is easily reduced by heating to low redness in hydrogen.

Method of Analysis.

The analysis was made on material freed as far as possible by careful selection under the lens from crystals showing alteration or inclusions.

The finely-powdered mineral, dried at 110°, was reduced in a current of hydrogen. No fluorine could be detected in the sodium carbonate plug which was placed at the end of the combustion tube. The material after reduction was digested in aqua regia, to which tartaric acid was added, and the solution was filtered off from some insoluble siliceous impurity (6·37 per cent.), the weight of which in the calculation of the analysis was deducted from the weight of material taken. The antimony was precipitated by sulphuretted hydrogen, and weighed as black sulphide after heating in carbonic acid. After weighing, the precipitate was fused with sodium carbonate and sulphur, and a little titanic acid was separated. No lead could be detected. The filtrate from the sulphide of antimony was made alkaline with ammonia, and a portion of the calcium which came down as tartrate was collected, ignited, re-dissolved, and finally

precipitated by ammonium oxalate. The iron and manganese were precipitated by ammonium sulphide, and the titanium, after the destruction of the tartaric acid, by a double precipitation with ammonia. In the filtrate the calcium and alkalies were determined in the usual way. 0·0982 gr. of the mineral was tested for fluorine by fusing with sodium carbonate and finally precipitating with calcium chloride. The precipitate dissolved to a clear solution in water acidified with acetic acid; and although a very slight residue, insoluble in water, was obtained on evaporating to dryness and treating with water, no fluorine could be detected in it by the microchemical barium silico-fluoride test.

Result of Analysis.

	I.	II.	Calculated for $5CaO, 3Sb_2O_5, 2TiO_2$ III.
Sb_2O_5	67·52	65·52	68·42
TiO_2	11·35	11·70	11·70
CaO	15·93	15·47	19·88
FeO	4·55	6·79	—
MnO	0·38	—	—
Na_2O	0·99	1·06	—
	100·72	100·54	100·00

Analysis I. was made on 0·5429 gr. of material dried at 110°.

Under II. is given the result of a preliminary analysis made on 0·2259 gr. of a different sample of material, which had been ignited.

The numbers under I. correspond approximately to the formula 5RO, $3Sb_2O_5$, $2TiO_2$, or 3(RO, Sb_2O_5), 2(RO, TiO_2), the calculated percentages for which are given under III.

The mineral is thus a titano-antimonate of calcium and iron, related on the one side to the calcium titanate perofskite, and on the other to the calcium antimonates atopite and romeite; it may also be said to be connected with the pyrochlore group of minerals, with antimonic acid replacing niobic acid.

At the time when the above analyses were made, no mineral of similar composition had been described, but in the last number of the Journal of the Geological Society of Stockholm (*Geol. Fören. Förhand. Stockholm*, XVII. (1895), pp. 313-18) there appears an account by Prof. H. Sjögren of what proves to be a very closely allied mineral, a new titano-antimonate from Jakobsberg, to which he has given the name Mauzeliite. It is iso-

metric, of brown colour, with specific gravity 5·11, and has the following chemical composition :—

Sb_2O_5	...	...	59·25
TiO_2	...	...	7·93
PbO	...	...	6·79
FeO	...	...	0·79
MnO	...	...	1·27
CaO	...	...	17·97
MgO	...	...	0·11
K_2O	...	...	0·22
Na_2O	...	...	2·70
H_2O	...	. .	0·87
F	...	...	[3·63]
			101·53
−O for F			1·53
			100

The composition of the two minerals is thus very similar, but the larger amount of iron and the absence of lead and fluorine serve to distinguish the Brazilian mineral from the Mauzeliite.

We have given the name of Lewisite to this new titano-antimonate from Brazil in honour of Prof. W. J. Lewis, during whose tenure of office the study of Mineralogy in the University of Cambridge has been so much encouraged.

Besides the Lewisite, in the heavy sand derived from the washing of the gravel from the small hill at Tripuhy were found the following minerals :—

(1.) Xenotime occurring sparingly in elongated prismatic crystals from 2 to 3 mm. in length, showing the combination {110} and {111}, and more rarely extremely small and narrow faces {331} and {311}. The crystals are translucent and of wine-yellow colour, and have a very distinct prismatic cleavage. A measurement on one of the crystals of the pyramid angle $(111 : \bar{1}11)$ gave 82° 12′.

In form and appearance the xenotime crystals strongly resemble those of the diamond sand of Dattas, near Diamantina.

(2.) Monazite is fairly abundant in light sulphur-yellow and yellowish-brown crystals, from 1 to 2 mm. in length. Two types of crystalline

form were distinguished: (*a*) tabular parallel to *a*(100), resembling turnerite, of yellowish brown colour, completely transparent, and free from inclusions; (*b*) prismatic by extension of *v*($\bar{1}$11), like the crystals from Alexander Co., N.C., of sulphur-yellow colour, and rich in inclusions of magnetite grains.

The following angles were measured on these crystals:—

	(*a*.) Turnerite type.		(*b*.) Alexander Co. type.
	Measured.	Calculated (Des Cloizeaux).[1]	
al	25° 4′	25° 14′	...
an	61° 38′	62° 4′	...
bn	28° 36′	27° 56′	...
bv	54° 2′	53° 22′	...
bu	30° 6′	29° 11′	...
be	48° 31′	48° 10′	...
ar	49° 16′	48° 3′	...
ae	80° 58′	79° 47′	...
av	61° 34′	61° 41′	61° 30′
ac	80° 24′	79° 47′	...
aw	39° 22′	39° 17′	39° 17½′
vv	...	73° 16′	73° 11′

The letters are those used in *Dana's Mineralogy* (6th ed.), p. 750, figs. 3-7.

Of the crystals of the turnerite type, only one very rich in faces was found suitable for measurement, and this, in spite of its favourable appearance, gave, on account of the imperfect development of the faces, great variations in the angles. This crystal showed the combination: *a*(100) predominant, *b*(010) tolerably broad faces, *n*(120), *l*(210), *v*($\bar{1}$11), *r*(111), *e*(011), *u* (021), *w*(101), *x*($\bar{1}$01). The sulphur-yellow crystals of the Alexander Co. type were very poor in faces, appearing for the most part as monosymmetric prisms with end-faces of the combination *v*($\bar{1}$11) and *a*(100). Other combinations observed were: *v*, *a*, *w*: *v*, *a*, *w*, *x*: *v*, *a*, *w*, *x*, *b*.

(3.) Zircon: very rare, in small prismatic crystals of a wine-yellow colour.

(4.) Kyanite: very abundant, in transparent colourless to dark grey tabular crystals of the thickness of a sheet of paper. The crystals often become opaque from included grains. Of especial interest is the not in-

[1] *Man. Min.*, II., p. 472.

frequent occurrence of geniculated contact- and penetration-twins, precisely agreeing with those first described by Kenngott, and later by M. Bauer, with the face $y(\bar{1}\bar{2}1)$ as twinning plane. Measurements of the angle $M{:}M$ on three crystals gave 62° 46′ to 62° 56′, agreeing very closely with the value calculated by Bauer. (Compare also Hintze, *Mineralogie*, p. 160, fig. 63.)

(5.) Tourmaline: rare, in microscopic dark brown prisms, mostly broken.

(6.) Rutile: tolerably abundant, in prismatic crystals from 1-3 mm. in length, for the most part tabular parallel to one of the prism faces, and then also often with two faces of the pyramid $s(111)$ prominently developed, so as to give an apparently monosymmetric character. The minute crystals are very rich in faces; the observed forms were: $a(100)$, $m(110)$, $l(310)$, $s(111)$, $e(101)$, $t(313)$; twinning, according to $e(101)$ and $v(301)$, very frequent.

(7.) Hæmatite: with quartz and muscovite forms the principal part of the heavy residue of the gravel. Well formed crystals of the combinations c, r, n, and c, m, a occur, and show a distinct polysynthetic twinning striation according to r, along which the crystals part readily.

(8.) Iron-pyrites: tolerably abundant, in crystals rarely exceeding a millimetre in greatest diameter, and always altered to dark brown limonite. The crystals show the combination $e(210)$, $a(100)$, $o(111)$.

(9.) Magnetite: very abundant, in very small octahedral crystals, rarely altered to martite.

(10.) Gold: very rare, in thin compressed flakes.

(11.) Finally, from this locality we have a new titano-antimonate of iron, the composition of which has not yet been accurately determined owing to lack of material.

The mineral occurs in extremely slender and very fragile hexagonal prisms, about 2 mm. long, of a resinous black colour, on which as terminal faces only the base has thus far been observed, since the slender needles are almost invariably broken and show a conchoidal fracture.

The crystals appear to be rhombic, the mean of several measurements of the remarkably lustrous prism faces over (010) being 91° 58½′. In combination with the prism is almost always the macropinacoid $\{100\}$, parallel to which the crystals are often tabularly developed. The rare basal face is arched and rough, so that no measurements could be made.

On account of the friability of the mineral, no optically orientated sections could be prepared, so that the reference to the rhombic system is not beyond doubt. In thin splinters the mineral is translucent, with a

dark brown colour; it is optically biaxial, with strong double refraction. It has a well developed conchoidal fracture without distinct cleavage. A rare twinning intergrowth according to a brachydome face, by which two prisms flattened along $a(100)$ cross at an angle of $60\frac{1}{2}°$ (measured under the microscope), is noteworthy. The density (weight of 1 cc.) was 4·529 at 22° C. as determined on 0·1121 gr.

The result of a qualitative and partially quantitative analysis, made on 0·0761 gr. of material, showed the presence of oxide of antimony with FeO (about 40 per cent.) and TiO_2 (about 17 per cent.).

Of the above minerals, the three first, xenotime, monazite and zircon, presumably come from rocks of a granitic character, for O. A. Derby (*Am. Jour. Sci.* XXXVII. p. 109 and XLI., p. 308) has shown that these minerals, particularly xenotime and monazite, are very characteristic of certain types of granite.

A search for exposures of granite in the vicinity, however, proved fruitless.

The other minerals are undoubtedly derived from the argillaceous mica-schist which passes into itabirite.

The state of preservation of the above minerals from the gravel warrants the conclusion that they have not suffered long transportation, but have been deposited close to their place of origin as the gravel, derived from the weathering of the schist and the included quartz veins, was formed. The crystalline form of all is well preserved, even the cinnabar fragments presenting sharp angles. The Lewisite probably comes, like the cinnabar and gold, from the quartz veins.

The occurrence of antimonates with gold has already been observed by Dr. J. C. da Costa Sena at Sao Bartholomeu, near Ouro Preto, only a few miles distant from Tripuhy.

II. ZIRKELITE.

A new calcium zirconate and titanate.

This mineral was found with baddeleyite, perofskite, etc., in the decomposed magnetite-pyroxenite of Jacupiranga, S. Paulo, Brazil.

A brief preliminary notice of it has already been given by one of us in a paper describing the new zirconia mineral baddeleyite and its associated minerals (*Tschermak's Min. u. Pet. Mitth.* XIV. pp. 408-10).

Physical Characters.

Crystal system, cubic, the only observed form being $o(111)$. The crystals are always flattened parallel to an octahedral face, and are

deeply striated parallel to the same face in virtue of polysynthetic twinning. Twinning according to $o(111)$ is very common, the forms being simple spinel-like types and complicated fourlings.

The cubic faces show by their striation the intergrown octahedra, and are truncated by brilliant octahedral faces. Cleavage, none; fracture, distinctly conchoidal; lustre, resinous; colour, black; opaque, except in very thin splinters, which are translucent with a dark brown colour, and isotropic; colour of powdered mineral, dark brownish-black, non-magnetic except when containing included grains of magnetite.

Density (weight of 1 cc.)=4·706 at 18°, as determined on 0·5287 gr. hardness, 5·5; brittle.

Chemical Characters.

Heated in closed tube, unaltered; before the blowpipe fuses with difficulty on the edges; insoluble in acids; decomposed by fusion with acid sulphate of potassium.

Method of Analysis.

The finely powdered mineral was fused with acid sulphate of potassium, and the melt dissolved in cold water. Owing to the peculiar behaviour of titanic acid when mixed with zirconia, the former was not precipitated by boiling the dilute solution. The titanic acid, zirconia, and iron were therefore precipitated together by ammonia, the precipitate re-dissolved, and re-precipitated. In the filtrate the calcium and magnesium were determined by the usual methods. The zirconia and titanic acid were separated from the iron by precipitation with sodium thiosulphate. The separation of the zirconia and titanic acid was attempted by a combination of the hydrogen peroxide method of G. H. Bailey (*Jour. Chem. Soc. 1886, Trans.* XLIX. pp. 149, 481) and the acetic acid process of G. Streit and B. Franz (*Select Methods of Chemical Analysis*, Crookes, 2nd ed. p. 98). The greater part of the zirconia was first precipitated by hydrogen peroxide, and the titanic acid precipitated by long continued boiling of the filtrate strongly acidified with acetic acid. Owing to the imperfect method of separation and to the small amount of material used in the analysis, the individual numbers for the zirconia and titanic acid can only be considered as approximate.

Result of Analysis.

ZrO_2 }	79·79	48·90
TiO_2 }		30·89
FeO	6·64	
CaO	11·61	
MgO	0·49	
Loss on ignition ...	1·02	
	99·55	

Weight of material used in analysis, 0·2256 gr.

We have dedicated this new zirconia-mineral to Professor Ferdinand Zirkel, of Leipzig (under whom one of us had the privilege to study), in commemoration of his great services in the microscopic investigation of minerals and rocks.

OBITUARY.

James Dwight Dana.

PROFESSOR James Dana, one of the original corresponding members of this Society, died on the 14th April, 1895, in the 83rd year of his age.

The great loss which his death has inflicted upon science in general has been so widely acknowledged, his eminence as a geologist, a zoologist, and a mineralogist has been so universally commemorated, and the history of his life has already been so well recorded in scientific journals, that it will be sufficient in this brief notice merely to attempt some estimate of the work which this great man effected in the sphere of mineralogical science.

For a full account of his life and labours the reader may be referred to the excellent obituary notice published in the *American Journal of Science*, of which he was an editor for no less than 50 years.

James Dana was attracted to the study of minerals early in life, and in 1833 was working under Professor Silliman at Yale College.

In 1836 he was Silliman's assistant in chemistry, and in 1837 he published the first edition of his *System of Mineralogy*, which afterwards became so well known. At that date the book failed to find a publisher, and was printed at the expense of the author. The system of classification at first adopted was to a certain extent modelled on the Natural History System of Mohs, which classified minerals by their external characters alone. As is well known, the adherents of that system attached absolutely no importance to the chemical characters for purposes of classification, and but little for purposes of identification. But already in Dana's second edition, which was published in 1844, a footnote in the introduction (p. 18) shows that the young author was dissatisfied with the methods of that school. He there says of the chemical characters: "They require for their determination a destruction of the individual, and have therefore been rejected by many distinguished mineralogists who would confine themselves to natural history, or external, characters. After much examination, with prejudices at the time in favour of the above views, I am fully convinced that these alone are insufficient for the determination of many mineral species, often so Protean in so many of their characters."

This was the first protest on the part of the author against the prevailing views; but in the third edition (1850) the revolution was complete; in the preface to that edition occur the following memorable words, which are so characteristic of Dana's mental attitude towards scientific problems that we quote them in full. "To change is always seeming fickleness. But not to change with the advance of Science is worse; it is persistence in error; and, therefore, notwithstanding the former adoption of what has been called the Natural History System, and the pledge to its support given by the author in supplying it with a Latin nomenclature, the whole system, its classes, orders, genera, and Latin names, have been rejected; and even the trace of it which the synonymy might perhaps rightly bear has been discarded."

It must be remembered that this was written two years before the publication of Rose's Krystallo-chemisches System, which also adopted the chemical composition and the crystalline form as the basis of classification.

Here was in fact an instance of Dana's chief strength; unlike those lesser workers who lose themselves amongst details, or blindly follow other leaders, he was quick to master the details, however great their complexity, to take a wide survey of the subject, and relying on his own judgment to select promptly what was right and essential.

His System rapidly became recognised as the standard Treatise on Mineralogy, and through successive editions has retained its pre-eminence. It is to be regretted that the introductory chapters on Crystallography, Crystallogeny, Chemical and Determinative Mineralogy, &c., which formed so important a part of the earlier editions, were subsequently omitted when the book assumed larger dimensions, for they were filled with useful information and speculations of great interest. Some of these were treated in separate memoirs published at various dates between 1835 and 1874, chiefly in the *American Journal of Science*.

Comparatively few discoveries or original investigations in mineralogical science are associated with the name of James Dana; his mineralogical work was mainly systematic, but it came at a time when, if ever, system was needed, and has done much to raise mineralogy to a position of dignity among the sciences.

It is highly improbable that any individual in the future will achieve such pre-eminence in the three sciences of geology, zoology and mineralogy; it is doubtful whether any individual since the time of Haüy has rendered more substantial and enduring services to the study of minerals.

H. A. Miers.

NOTES AND COMMENTS.

WE note with regret the death of Francesco Sansoni, Professor of Mineralogy in the University of Pavia. He died on the 28th of March, 1895, at the age of 42; his name will chiefly be associated with the *Giornale di Mineralogia*, of which he was the founder and editor; among his published memoirs the most noteworthy are those upon the crystallography of calcite; during a period of three years Dr. Sansoni, before his appointment at Pavia, was occupied in examining calcite in various European collections, and some results of his studies have been published at intervals during the last few years.

We have received notice of the death of Professor Hermann Knoblauch, the distinguished President of the Kaiserliche Leopoldinisch-Carolinische Akademie, who died on the 30th of June in the 76th year of his age. Also of the death, on the 26th of June, at the age of 27, of Gustav Nordenskiöld, son of the famous Mineralogist and Arctic Explorer, Baron A. E. Nordenskiöld, and himself a Mineralogist of some reputation.

Dr. Richard Brauns, formerly at the technische Hochschule in Karlsruhe, has been appointed Professor of Mineralogy and Geology in the University of Giessen, in succession to Professor A. Streng, who has been compelled to resign on account of ill-health.

Dr. N. V. Ussing becomes Professor of Mineralogy at Copenhagen, in succession to the late Dr. Johnstrup.

Dr. Koken has been appointed to the Chair of Mineralogy and Geology at Tübingen, where he succeeds Professor Quenstedt; Dr. K. Oebbeke, of Erlangen, has been appointed Professor of Mineralogy at the technische Hochschule, of Munich, where he succeeds Professor Haushofer; and Dr. K. Futterer, of Berlin, enters upon similar duties at the technische Hochschule of Karlsruhe.

Copies have reached us of recent numbers of the two youngest English magazines which deal with general science, namely *Science Progress* and *Natural Science*. Almost every number of the former journal contains articles of mineralogical and geological interest in the form of critical summaries of recent discovery.

The July number (No. 41) of *Natural Science* consists mainly of an interesting series of authoritative articles upon the scientific results of the *Challenger* Expedition, among which we may specially call attention to an article on Coral Reefs by Prof. J. W. Judd, C.B., one on Chemico-biological changes in the Ocean by R. Irvine, and one on Marine Deposits by J. Chumley.

We have received the first part of a new volume on Precious Stones, "Edelsteinkunde," by Prof. Max Bauer, of Marburg, which promises to be an important treatise, embellished with beautiful coloured plates: more detailed review is reserved for our next number.

Dr. Valentine Ball, C.B., F.R.S., Director of the Science and Art Museum in Dublin, died on the 15th of June, 1895, in the 52nd year of his age. He was Professor of Geology and Mineralogy in the University of Dublin from 1881 to 1883, and published numerous papers on geological and mineralogical subjects. His valuable treatise on the Economic Geology of India, in particular, is well known.

The veteran physicist F. E. Neumann died on the 23rd of May, 1895. So long a time has elapsed since the publication of his earliest papers in 1823, and his name has been so prominently associated with other branches of study, that his mineralogical work belongs to a bygone generation; it is difficult to realise that a man who was making most important contributions to physical crystallography seventy years ago could still be living in the present year.

Neumann was born in 1798, and was appointed to the Professorship of Mineralogy in Königsberg in 1828, having been attracted to that subject by Weiss.

REVIEWS.

A Treatise on the Morphology of Crystals: by N. Story-Maskelyne, M.A., F.R.S. (Clarendon Press, Oxford, 1895.)

The publication of Prof. Maskelyne's long anticipated treatise on morphological crystallography marks an era in the history of the science in this country. Hitherto the English student who desired to pursue the subject beyond the mere attainment of a superficial acquaintance has been obliged to have recourse to the admirable treatises in the German and French languages. This, however, is no longer necessary as far as the morphological side of crystallography is concerned, and we now have this fascinating subject most fully treated in our own language, and in an entirely original and delightful manner. The book is constructed upon the plan of the author's Oxford lectures, and those who have not been privileged to enjoy the lectures themselves may now follow the lecturer at their leisure through the wonderful maze of crystalline forms, and develop something of his own enthusiasm as he traces the interesting connection between them.

The basis of the book is eminently mathematical, yet the reasoning is usually sufficiently simple to be incapable of repelling those whose mathematical training has not been of an advanced character, while on occasion sufficiently deep to be a source of satisfaction even to the more mathematically inclined. An admirably lucid explanation of the stereographic representation of crystals is given, accompanied by a sufficient selection of theorems in pure spherical trigonometry to enable a beginner to readily work out any problem in practical crystallography which may present itself. Equally clear and precise are the sections which treat of the fundamental laws of crystal morphology, the rationality of indices, the zone law, and the law of anharmonic ratios, while the Millerian method of notation appears simplicity itself as explained by Prof. Maskelyne. There is, however, one point to which the attention of students about to use the book might with advantage be drawn. It is to some extent unfortunate that the nomenclature of the two lateral axes of a crystal employed by Prof. Maskelyne is the reverse of that adopted by Groth in his invaluable *Zeitschrift für Krystallographie*, and by the whole of the

modern German school. Whilst the axis passing from front to back of the crystal is termed the A-axis, corresponding to the Millerian plane (100), in the German scheme, and the axis passing from right to left is lettered B, corresponding to the plane (010), Prof. Maskelyne terms the former the B axis and the latter is designated A. So long as students are fully aware which scheme they are employing, it is of course a matter of no importance, although one cannot but regret that the two systems are not brought into unison, in order on the one hand to avoid confusion in comparing data from German and English sources, and on the other hand in order to save the considerable labour involved in a revision of the facial symbols in translating from one language to the other. For this reason the writer of this review has adopted the German scheme of lettering the lateral axes in all original communications.

Upon the chapters concerning the symmetry of crystals it would be almost impossible to bestow too much praise. The large importance attached to symmetry is indeed a feature of the book, and in carrying it to its logical conclusion Prof. Maskelyne is led to make a most interesting statement, almost prophetic, considering that this portion of the work has been in the press for some time, of the direction in which crystallographical research is now tending. Prof. Maskelyne speaks (p. 171) of crystal symmetry as a geometrical abstraction, which "needs for its development and due explanation a complete science of position applied to the molecular mass-centres, competent to embrace not merely the relative distribution *inter se*—the *intermolecular* distribution—of the chemical molecules constituting the crystallised substance, but also the *intromolecular* arrangement of the atoms, or molecules of secondary order, whereof the molecules of the substance are themselves composed. Then the true significance of the ideal planes and axes of symmetry will be understood, and they will assuredly retain a place in the explanation of crystalline symmetry, since they rise into recognition directly from the fundamental principle of rationality of indices, and are controlled by its consequences." It is somewhat to be regretted that Prof. Maskelyne has not found it convenient to follow up this prescient statement with a *resumé* of the attempts which are being made to-day to ascertain the nature of the molecular mass-centres, and to unravel the mode of distribution within them of the chemical molecules and the atoms of which the latter are composed. A criticism of these researches from his master mind could not fail to be of the greatest use to those who are engaged in attempting to penetrate into this obscure but fundamental region of morphological crystallography. Moreover, we miss in the present volume all allusion to

the remarkable mathematical investigations of Sohncke, Fedorow, and Barlow as to the possible modes of distribution in space of the molecular mass-centres. However, Prof. Maskelyne promises us a second volume, and doubtless will introduce into it, along with the consideration of the physical properties of crystals, these most interesting questions relating to their ultimate structure. For what can the morphology of crystals depend upon other than the nature, that is to say the internal structure—and all that this implies as regards the distribution of the matter composing it, the state of motion or equilibrium of the atoms, and the form, store and distribution of energy—of the organised aggregate of chemical molecules which is now currently regarded as the crystallographical unit or crystal-element? It must be that the forces which bind together these crystal units in such perfection of symmetry entirely depend upon the nature of the crystal element as thus defined, and that no comprehensive theory of the ultimate structure of crystals can be arrived at until more knowledge is gained as to the morphology of the crystal element itself.

In the latter portion of the book Prof. Maskelyne gives an admirably practical account of the use of the goniometer, including a full description of Websky's mode of adjusting the instrument. This is followed by a series of carefully chosen examples of crystallographical calculations, and an exceedingly useful account of the current modes of drawing crystals from the ascertained crystallographic elements. It is earnestly to be hoped that Prof. Maskelyne will see his way to complete the further volume in the near future, when he will have made the most important addition to the crystallographical literature of this country since the publication of the fundamental work of Miller. A. E. Tutton.

An introduction to Chemical Crystallography: by Andreas Fock, Ph.D., translated and edited by W. J. Pope. (Clarendon Press, Oxford, 1895.)

Mr. Pope has rendered a great service to Chemical Crystallography by his translation of the work of Dr. Fock. It is still, unfortunately, a matter of regret that, owing to our totally inadequate methods of secondary education, comparatively few students in this country are enabled to read continental authors in the original, and many who are consequently unable to peruse with advantage the compact little book of Dr. Fock, and the still more recent and comprehensive treatise of Prof. Arzruni of Aachen, will feel indebted to the translator of the former. The relationship between chemical composition and crystalline form is as yet so little understood, that no book on the subject can hope to do more than present a clear idea of the stage to which investigation has reached, and the

direction in which it is tending. The opportunities which are afforded to the chemical investigator of studying the crystallographical properties of definitely related substances which he prepares in the course of his synthetical operations, are so numerous that it is greatly to be desired that every student of chemistry who intends to pursue the subject should take up as part of his training a course of practical crystallography. For, as Prof. Maskelyne very truly remarks in a preface with which he introduces Mr. Pope's translation, the crystallographical and physical constants of the new substance are as much a part of its nature as its composition and chemical relationships.

The earlier chapters of the work are devoted to the history of the science, to the modes of formation of crystals, the influence of water of crystallisation upon the geometrical form, and the current views as to the state of the included water. Double salts are next considered in the light of the recent work of Rüdorff, Trevor and Willard Gibbs, and the four conditions of saturation-equilibrium for the pair of simple salts constituting the double salt discussed. Very interesting chapters then follow on the growth of crystals and the nature of crystallites, and a full account is given of the recent explanation of the phenomena by Lehmann on the basis of the variations in the concentration of the environing solution. The most important portion of the book, however, is that which connects crystalline form with chemical composition, and here again very considerable additions to the text have been made by Dr. Fock, and also, with his sanction, by Mr. Pope, in order that the most recent investigations shall be included. The work of Muthmann upon the arsenates and phosphates, and of the writer of this review upon the sulphates and double sulphates containing potassium, rubidium and cæsium, is discussed, and, in short, the translation affords a fairly complete account of the subject up to date. Perhaps one small oversight might be mentioned. On page 104 occur the words: "Although no close relationship can be observed between the indices of refraction of the three salts, yet it will be seen that the refractive indices of rubidium sulphate are intermediate between the corresponding indices of potassium and cæsium." As a matter of fact, they do bear a most interesting relationship, which is fully discussed in the memoir referred to, and is clearly seen when they are graphically represented by curves, and still more clearly when the corresponding optical elasticity relationships are calculated from them and similarly expressed by curves. The change of atomic weight of the metal is indeed most accurately reflected in the optical behaviour of the three salts, and is directly responsible for the beautiful and quite exceptional optical characters of rubidium sulphate.

The nature of physical isomerism, formerly termed dimorphism, affords the subject for another particularly interesting chapter, and although the distinction of Lehmann between physically polymeric and physically metameric substances would appear at present to be of a somewhat superfine character, still it can no longer be doubted that the phenomenon of a single chemical substance crystallising in more than one crystalline form depends essentially upon a different constitution of the crystal-element, the physical molecule, whether the difference is in the number or the arrangement of the chemical molecules of which it is composed. So soon as a satisfactory method is discovered of determining the composition of the physical molecule, we shall be able to to solve this, as well as many other problems of great interest. Indeed, it would seem that such a method is the great desideratum at the present moment, and it will be of distinct service if the translation of Dr. Fock's book calls attention to the fact. The concluding chapters on isogonism and morphotropy afford still further food for thought, and here again it is shown that there is much probability in the supposition of Groth that the crystal-elements of morphotropic substances are of the same magnitude, and that, therefore, the explanation of morphotropy will in all likelihood follow the discovery of a method of determining that magnitude.

The translation of Mr. Pope has a further advantage over the first edition of the original, besides the fact that it is in our own language, inasmuch as many errors, typographical and otherwise, had crept into the German text; these are all corrected, and Mr. Pope has had the additional good fortune to find in Mr. Miers, of the British Museum, an experienced friend to assist him in the revision of the manuscript and proofs.

A. E. Tutton.

Recherches Minéralogiques of Prof. M. Tolstopiatow. Posthumous edition, pp. xxviii., 136. Moscow, 1893.

M. Tolstopiatow, who was for 30 years Professor of Mineralogy in the University of Moscow, seems to have published comparatively little of his work, but left behind him, at his death in 1890, numerous papers and notes. These, which are somewhat fragmentary in places, have been collected and edited by M. Kriloff to form, together with a biographical notice, the present volume. His favourite subject related to crystallogenesis and the structure of crystals, but a large part of the book is taken up by his observations on the *absorption brushes of epidote*. The latter subject commences with a historical review, in which it is pointed out

that some previous observers have confused the true absorption brushes with the idiocyclophanic pictures seen in epidote, and with the interference phenomena due to polarised light from the sky and the polarising action of the crystalline lens of the eye (to which Haidinger's brushes are due). Mention is made of Bertrand's statement that absorption brushes are to be seen in dichroic uniaxial crystals, as well as in biaxial crystals; this, however, is doubted. Instead of cutting plates perpendicular to the two optic axes, the author has preferred to view the unprepared crystals through the faces c (001) and r ($\bar{1}01$), these being nearly perpendicular to the two optic axes. The same crystal can then be viewed along both axes, with the result that, owing to the twinning of epidote, differences in the two sets of brushes can be seen. The crystals are viewed in ordinary and in polarised light (from the sky or with a nicol), and several beautifully coloured plates are given of the absorption and interference phenomena seen. The "primary" or absorption brushes, which depend on the unequal absorption of the two rays, are disposed in the direction of the orthodiagonal of the crystal (epidote), and do not change their position when a nicol placed in front is rotated, there being only a transposition of the colours. The brushes are often more distinct when viewed through one face than when viewed through the parallel face. The "secondary" or interference brushes (idiocyclophanic), due to an enclosed twin lamina, are of comparatively rare occurrence. It is here supposed that the light is polarised in the crystal, not by the greater absorption of one ray, but by the twin laminæ, with layers of air or of decomposed epidote between, acting as a pile of plates. Notes are also added on the polarisation of the atmosphere, and on the brushes seen in lepidolite and muscovite in natural light.

The second part of the volume, on *the structure of crystals*, is very hypothetical, and commences with the assertion that crystals are not homogeneous, but consist of a nucleus and an envelope, the former being regularly constituted, and the latter irregularly—in fact, a sort of accidental growth. This nucleus, which is called the *cryptopyramid*, and denoted by kP, is said to manifest itself, and to be distinguished from the envelope, by differences of colour, dichroism, arrangement of enclosures, cleavage, fracture, and character of the optic pictures (*e.g.* when the nucleus is uniaxial, the envelope is biaxial; variation of the value of 2 E, as in topaz), these being taken to indicate differences in structure of the two parts. This important crystallographic unit, said to be the primitive form (from which the parametral ratios are calculated in terms of the number of molecules along the axes), can sometimes actually be seen in

the interior of a crystal as an acute elongated pyramid, singly (in this case taken to indicate hemimorphism, *e.g.* calcite) or doubly terminated. Much importance is also attached to complicated systems of striæ seen in the interior of crystals.

There are also notes on hemimorphism, twins, pleochroism, asterism, &c. From the character of the "cryptopyramid" topaz is regarded as hemimorphic. From certain fissures and marks on the faces it is inferred that topaz is twinned, showing both polysynthetic and crossed twins. L. J. S.

Abstracts.

New Minerals from Greenland (G. Flink, *Zeits. für Kryst.* XXIII. 344, 1894).—The exact locality is not certain; but as the minerals occur in cavities (which are not known in the syenitic pegmatite veins of Kangerdluarsuk) and are associated with certain minerals known to occur at Narsasik near Igaliko, they probably come from the latter locality.

Neptunite.—This new mineral occurs as brilliant black crystals of a vitreous lustre on ægirine and orthoclase; the habit is octahedral, owing to the equal development of the forms c (001), m (110), u ($\bar{5}12$), d ($\bar{3}01$), which are present on all crystals.

$$a : b : c = 1{\cdot}31639 : 1 : 0{\cdot}8075;\ \beta = 64°22'$$

Cleavage m perfect; sp. gr. 3·284. In thin sections is blood-red by transmitted light and pleochroic; optically positive. The formula is given as:—

$$TiO_3\,(\tfrac{2}{3}\,Fe + \tfrac{1}{3}\,Mn).Si_4O_9\,(\tfrac{3}{4}\,Na_2 + \tfrac{1}{4}\,K_2),$$

which may also be written as a titano-silicate. Owing to the close similarity of the crystal angles to those of sphene, neptunite is placed in the titanite group.

Epididymite.—This new mineral has the same composition ($BeNaHSi_3O_8$) and density (2·55) as eudidymite; the two, however, differ in crystalline form and the optical constants, the former being ortho-rhombic and the latter mono-symmetric. Epididymite occurs as colourless crystals deeply striated and elongated parallel to the macrodiagonal.

$$a : b : c = 1{\cdot}7367 : 1 : 0{\cdot}9274.$$

Twins have the individuals crossing at nearly 60°, as in eudidymite; but twinning is mostly only seen in polarised light as crypto-twinning. Very perfect cleavage parallel to the base and macropinacoid. Optically negative. A more or less close relation is shown to exist between the crystal angles of epididymite and eudydimite.

Catapleiite, which was only before known from Norway, is described from this locality as large hexagonal tables with the hexagonal pyramid

(522). Through the basal plane a biaxial optic picture, with small axial angle, is seen. Analysis shows it to be soda-catapleiite.

The *ægirine* crystals are described, and three types distinguished, depending on the habits of the crystals and the optical relations. Descriptions are also given of the other associated minerals. L. J. S.

Gold.—The following series of papers is communicated by A. Liversidge to the *Jour. Roy. Soc. N. S. Wales*, 1893, pp. 1-61 :—

Origin of Moss Gold.—After roasting auriferous mispickel, at a temperature below the melting point of gold, the specimens are seen to have ochre-coloured exudations on their surfaces; these consist of gold in cauliflower-like aggregations, and under the microscope are seen to be made up of spicules and spirals of gold. The same result is obtained on roasting a mixture of gold and mispickel.

When arsenic vapour is passed over gold foil, at a dull red heat, yellow brittle globules of a very fusible arsenide of gold (with 2—10 % As) are formed. On cooling, the globules spurt and give off arsenic, giving rise to the lustreless excrescences of moss gold, while cavities contain spirals and spicules of gold. A similar phenomenon is seen in fused bituminous coal and the forms assumed by the resulting coke. The gold in auriferous mispickel appears to be in the free condition, and to be converted into the fusible gold arsenide on roasting.

The condition of gold in quartz and calcite veins.—In order to ascertain whether the gold scattered through quartz veins and other gangues is crystalline or not, the matrix was dissolved away by hydrofluoric or other acid. The gold thus set free from quartz usually presents the appearance of irregular films, plates, threads and masses which are more or less connected together, or as dull brown powder, and only rarely showing any signs of crystallisation, the two minerals having apparently solidified together, neither being able to crystallise freely.

The really good crystals of gold all appear to have formed in what are now cavities, usually left by the removal of iron pyrites, or else in soft matrices like iron oxides, clay, calcite and serpentine.

Origin of Gold Nuggets.—Besides the old and generally accepted view that alluvial gold has been set free from mineral veins and rocks by denudation, various theories have been put forward to explain its origin, the principal one being that of Dr. A. R. C. Selwyn, who suggested that nuggets grow in alluvial deposits by the deposition of gold, from solution on their surface. The author gives an exhaustive and critical review of

the literature bearing on the subject, and adds numerous careful experiments of his own.

Various metallic sulphides (pyrites, galena, &c.), on being placed in a solution of double chloride of gold and sodium, soon become coated with reduced gold, either as a bright coherent deposit, or as a dull ochre-coloured one. On placing in the solution a gold nucleus (a nugget or plate) with inorganic matter (pyrites, mispickel, etc., graphite, sand, clay, granite, etc.) with the object of forming a galvanic couple, dull gold with a mamillated structure was deposited on the nucleus as well as on the inorganic matter. With organic matter gold was reduced but none deposited on the nucleus, as has been stated to be the case by previous authors. Having shown that gold can be deposited from solution on a nucleus of gold, the author discusses the evidence of the existence of gold in natural waters. Only in sea water is there direct chemical evidence of the presence of gold, nevertheless it must have been present in the water from which recent auriferous pyrites, &c. has been deposited; and it is now being deposited by the hot springs of Nevada and California. Gold is soluble in solutions of alkaline sulphides, carbonates and silicates.

The author has thus shown that it is theoretically possible for nuggets to have grown *in situ*, but he is of the opinion that large nuggets at least have not been formed in this way, but have been derived from reefs, and that any small addition of gold they may have derived from meteoric waters is quite immaterial. Against the arguments used in favour of the theory of growth *in situ*, it is pointed out that the difference in composition of nugget and vein gold is usually small, and sometimes vein gold is even richer than alluvial. The roughnesses of vein gold would be flattened down by abrasion, the water-borne sand and pebbles acting in every crevice; the surface of the malleable gold would thus assume a mamillated appearance. Masses of gold have been found in veins comparable in size with the largest nuggets. In favour of the old theory it is pointed out that large nuggets have some reef quartz attached to them; besides, the pebbles of gold-bearing alluvium are admitted to have come from gold reefs; that being so, why should we seek for another origin for the associated water-worn pebbles of gold? And why is alluvial gold not found as plates and strings if it has been deposited *in situ?*

Crystallisation of Gold in Hexagonal Forms.—The gold deposited on various metallic sulphides (copper pyrites, blende, &c.) placed with a gold nucleus in a solution of gold (*v. supra*) took the form of bright minute prisms, six-rayed stars, and hexagonal plates. "In no case were there any traces of gold in forms belonging to the cubical system,"

although these are so readily obtained by reducing gold with ether, oxalic acid, &c. Such hexagonal forms have been previously recorded, and are regarded by E. S. Dana to be due to elongation or compression along a trigonal axis.

Gold Moiré-métallique.—In many cases the gold plates, used in the above experiments on the reduction of gold from solution, presented a moiré-métallique appearance, as seen on tin plates and galvanised iron. The whole surface of the plate being dotted over with more or less regular crystals, very small, and much more regular and rectangular in outline than those on tin plate. This effect may also be brought about by boiling pure gold foil or plate in hydrochloric acid. L. J. S.

Leadhillite from Missouri and its Chemical Composition (L. V. Pirsson and H. L. Wells, *Am. J. Sc.* XLVIII. 1894, p. 219). — This rare mineral occurs with cerussite at a new locality, Granby, Missouri, in rather slender, apparently hexagonal prisms, attaining a length of 5 cm., or more commonly in thick hexagonal tables 1 cm. across. The colour varies from colourless in the smaller transparent crystals to clear sea-green in the larger translucent individuals. The usual forms present are the basal plane, unit prism and orthopinacoid, with sometimes hemidomes and pyramids (e ($\bar{2}01$), u (201), q ($\bar{4}14$), μ ($\bar{4}18$)). The angle β was measured as 89°38′. Twinning on the unit prism is common, often giving rise to twin lamellæ; the scattered images of the goniometer signal from the perfect basal cleavage of such individuals show the mineral to be oblique (the measured angles closely approach those required by hexagonal symmetry). Twins with the basal plane as the plane of combination are sometimes indicated by the optic pictures being crossed at 60°, as in mica. The mineral becomes uniaxial at a temperature below 100°C.; in the course of a day or so the uniaxial character disappears and the normal one is resumed. Etching figures on the basal cleavage agree with the oblique symmetry, and are very like those of mica.

Previous analyses of the mineral have varied somewhat widely, the earlier ones disregarding the water, so that various formulæ have been given. The present analysis agrees very closely with the simple formula assumed by Groth, $[SO_4]\ [CO_3]_2\ Pb_2\ [Pb{\cdot}OH]_2 = 4PbO{\cdot}2CO_2{\cdot}SO_3{\cdot}H_2O$. A large pure crystal was used, the water and carbon dioxide being driven off by heat and weighed directly, and the ignited residue fused with sodium and potassium carbonates. Sp. gr. 6·54. L. J. S.

Sulfoborite (H. Bücking, *Sitz. k. preuss. Akad. Wiss.* XLIV. 967,

1893). This new mineral has been found at Westeregeln with celestine, the latter not having before been noticed from the Egeln-Stassfurt salt beds. The colourless or reddish isolated crystals belong to the orthorhombic system, and five habits, depending on the relative sizes of the unit prism and pyramid, and the brachypinacoid and basal plane (which are the only prominent forms) are figured :

$$a : b : c = 0{\cdot}6196 : 1 : 0{\cdot}8100.$$

The cleavage (101) is good, that parallel to the basal plane is less perfect. Sp. gr. 2·38 to 2·45. The chemical formula is given as $3MgSO_4 \cdot 2Mg_2B_4O_9 \cdot 12H_2O$. This is the representative of a new mineral group analogous to the mixed borate and phosphate of magnesium, viz. lüneburgite. L. J. S.

Crystallographic determinations of new Chilian Minerals (A. Osann, *Zeits. für Kryst.* XXIII. 584, 1894).—These minerals from the salt beds of Chili have recently been described by A. Dietze (*Zeits. Kryst.* XIX. 445, 1891), and are interesting as representing new groups of minerals.

Darapskite.—Composition: $NaNO_3 + Na_2SO_4 + H_2O$. The colourless mono-symmetric crystals are tabular parallel to the orthopinacoid, and the principal forms are in the orthodome and prism zones—

$$a : b : c = 1{\cdot}5258 : 1 : 0\ 7514; \ \beta = 77°5'.$$

Twinning on the orthopinacoid is frequent, sometimes as polysynthetic twins; the same face is also parallel to the cleavage. Sp. gr. 2·203. The locality is Pampa del Toro, where also good crystals of Blödite occur.

Lautarite.—Composition: $Ca(IO_3)_2$. The transparent wine-yellow to almost colourless crystals are mono-symmetric with prismatic habit, and terminated by a large basal plane and small unit clinodome faces, the latter being parallel to the cleavage. Sp. gr. 4·59.

$$a : b : c = 0{\cdot}6331 : 1 : 0{\cdot}6462; \ \beta = 73°38'.$$

Dietzeite.—Composition: $7\ Ca(IO_3)_2 \cdot 8\ CaCrO_4$. This mineral occurs in fibrous aggregates, and is of a dark gold-yellow colour; distinct crystals, which are mono-symmetric and tabular parallel to the orthopinacoid, are rare.

$$a : b : c : 1{\cdot}3826 : 1 : 0{\cdot}9515; \ \beta = 73°28'.$$

An imperfect cleavage exists parallel to the orthopinacoid. Sp. gr. 3·698. The name dietzeite is proposed after the discoverer. L. J. S.

Chemical behaviour of Pyrites and Marcasite (A. P. Brown, *Proc. Am. Phil. Soc.* XXXIII. 225, 1894). An attempt is made, by means of numerous experiments, to arrive at the constitution of these bodies, it being remarked that little work has been done in this direction amongst minerals. In review are given the various methods which have been successful in the artificial production of pyrites, and it is noticed that marcasite has not been formed artificially. Their possible modes of formation in nature are also suggested, and their weathering discussed, it being noticed that pyrites gives rise to limonite (as is seen in the numerous pseudomorphs) and free sulphur, while the less stable marcasite gives rise mainly to ferrous sulphate with little limonite. In one series of experiments the minerals were treated with solutions of potassium permanganate of various strengths, and at various temperatures, with the object of oxidising the sulphur, but the curves plotting the results show no marked difference between pyrites and marcasite. Dry hydrochloric acid gas at an elevated temperature acted more readily on pyrites than on marcasite. The amount of ferrous and ferric iron in the minerals was determined by heating with copper sulphate solution in sealed tubes, and titrating with permanganate, and it was found that, while all the iron of marcasite existed in the ferrous state, only 8·91 per cent. of the iron in pyrites was in this state. Marcasite has then the formula $Fe''S_2$, and pyrites $4\,Fe''S_2 \cdot Fe''S_2$. The formula indicates that marcasite is an unsaturated compound, the two sulphur atoms being linked together, and thus may be explained its more unstable nature. L. J. S.

Lindesite (L. J. Igelström, *Zeits. für Kryst.* XXIII. 590, 1894). This mineral occurs in gneiss with other manganese compounds in the Glakärn mine, Linde, Örebro. The brownish-red crystals appear to be mono-symmetric or asymmetric, and have good cleavages in three directions. The important constituents are as follows, those of urbanite being added for comparison :—

	SiO_2	Fe_2O_3	MnO	CaO	MgO	Na_2O
Lindesite	48·37	21·92	10·97	5·76	3·49	6·12
Urbanite	51·61	27·24	1·73	4·90	2·95	10·59

The formula suggested is $3\,RO \cdot SiO_2 \cdot R_2O_3SiO_2$. The mineral approaches acmite and rhodonite. Urbanite was the name recently given by Sjögren to the so-called "iron-schefferite" of Långban. Should lindesite and urbanite prove to be identical, the author claims priority for the former name.

Pyrrho-arsenite. This mineral occurs with rhodonite in the Sjö mines, Grythyttan. The composition, which does not correspond very closely to that of an orthoarsenate, differs from that of berzeliite in containing more manganese (28·38 per cent.), and rather less calcium and magnesium, so that the mineral may be considered as a manganese-berzeliite. L. J. S.

Lossenite, a new Laurium mineral (L. Milch, *Zeits. f. Kryst.* XXIV. 100, 1894). Occurs as small, reddish-brown, lustrous, pyramidal crystals, strongly resembling scorodite in appearance, and often coated with brown ferruginous and olive-green decomposition products. Besides the unit orthorhombic pyramid, pinacoid (*a* (100)) and prism faces are sometimes present. Only rough measurements can be obtained between the pyramid faces, giving $a : b : c = 0{\cdot}843 : 1 : 0{\cdot}945$. These parameters are very close to those of scorodite, and the optical characters of the two minerals are identical. After deducting 1·13 per cent. of SiO_2 and 1·46 per cent. of $CaCO_3$, the formula is given as $2\,PbSO_4 + 6\,(FeOH)_3As_2O_8 + 27H_2O$. The mineral, to which the name *Lossenite* (after A. C. Lossen) is given, thus differs from scorodite by the presence of $PbSO_4$ and water of constitution, and in the greater proportion of water of crystallisation.

L. J. S.

Beryl from Pisek, Bohemia (C. Vrba, *Zeits. für Kryst.*, XXIV., 104-123, 1894). In the felspar quarries near this place occur two varieties of beryl—one, opaque common beryl, and the other transparent and yellow, or bluish-green noble beryl. The first is more or less decomposed, with bertrandite in cracks and cavities: one crystal proved to be a twin, which has not been before observed in beryl. The angle $2\bar{1}\bar{1} : 2\bar{1}\bar{1}$ between the two individuals of the twin was measured as 84° 55′, which agrees with (8, 47, $\bar{8}1$) being the twin plane, or the plane ($\bar{7}$, 8, 23) which is nearly at right angles to the last may be taken. The transparent crystals are deeply etched and corroded, but quite fresh. Measurements of the etch-faces are given, among which are several new forms.

Bertrandite from Pisek. In a new felspar quarry small crystals of bertrandite occur with crystals of albite and apatite in cavities having the shape of hexagonal prisms. These cavities are negative crystals after beryl, the decomposition of which has given rise to the bertrandite. The crystals are well developed, and tabular parallel to *b* (010). Simple crystals are rare, two to four individuals being twinned together with *e* (041) as twin plane. The crystals from several other new localities in

the felspar quarries near Pisek are described: at Ober-Neusattel large crystals occur, and here anatase, which is new to Bohemia, was found.

Phenakite from Ober-Neusattel. This occurs with the bertrandite, and in the same manner, having also been produced by the decomposition of beryl. Several crystals are figured and described, some of which are interpenetrating twins with parallel axes: $c=0{\cdot}660905$. Analyses of beryl and phenakite, agreeing closely with theory, are given.

L. J. S.

Crystallography of Cassiterite (W. Kohlmann, *Zeits. für Kryst.* XXIV. 350-365, 1895). Descriptions and measurements of crystals from numerous localities are given under Becke's three types, which are to a certain extent characteristic of special localities:—(1) Crystals with equal extension of the vertical and lateral axes, no basal plane, and frequently twinned (Erzgebirge); (2) "Needle-tin," with the acute pyramid (551) largely developed (Cornwall); (3) Basal plane prominent (Pitkäranta). A fourth type is added in which the pyramid *s* (111) predominates. This was observed by the author from Tasmania and Zinnwald. Of twin crystals, three habits of twinning are distinguished. A complete list of forms is given, with the evidence as to their first discoverers. A few new forms are given. The variations in colour of the mineral are described, and the colour of a yellow crystal from Perak, with 0·11 per cent. of WO_3, is doubtfully attributed to tungsten. The modes of occurrence and associated minerals from different localities are described.

L. J. S.

Breithauptite (K. Busz, *Neues. Jahrb. Min.* I. 119-124, 1895). —As crystals of this mineral have not been measured since Breithaupt's measurements in 1840, the author has examined a few very bright crystals, found embedded in calcite from Andreasberg. Breithaupt suggested the mineral to be isomorphous with pyrrhotite, and therefore gave the two pyramids the indices $i(411)$ and $w(8\bar{1}\bar{1})$, (with the dirhombohedra (011) and $(\bar{3}55)$); the prism $a(2\bar{1}\bar{1})$, and the basal plane $c(111)$ were also present: $a:c=1:0{\cdot}8586$. Groth supposed the mineral to be rhombohedral and isomorphous with millerite, in which case the pyramids and prism will be of the second order, with the symbols $a(01\bar{1})$, $c(111)$, $i(741)$, $w(13, 4, \bar{5})$; and $a:c=1:0{\cdot}9914$. The crystals measured by the author show no suggestion of rhombohedral symmetry, and they are not tabular in habit as those of Breithaupt, but pyramidal (w) truncated by the basal plane. The planes of the form w are smooth

and very bright near the basal plane, but towards the prism they are striated horizontally. The observed forms were $c(111)$, $a(2\bar{1}\bar{1})$, $w(8\bar{1}\bar{1})$, $s(5\bar{2}\bar{2})$. The mean of 11 measured angles for cw was 56° 10′ 40″ (limits 55° 58′ – 56° 30′), this gives $a : c = 1 : 0{\cdot}8618$. For ww' the mean of 9 measurements was 49° 7′ 20″ (limits 48° 41′ – 49° 15′), this gives $a : c = 1 : 0{\cdot}8636$. Taking the mean of these:

$$a : c = 1 : 0{\cdot}8627.$$

Placing the crystals in Groth's position, the symbol for s is $(23, 2, \bar{19})$, and $a : c = 1 : 0{\cdot}9962$.

A twin crystal, consisting of two equally developed individuals with w as the twin plane and face of composition, was observed: the forms present were w and c; $c\bar{c}$ measured 67° 42′, calculated 67° 35′.

A review of the literature of breithauptite and arite is given.

L. J. S.

Caledonite from Leadhills. (K. Busz, *Neues Jahrb. Min.* I. 111-115, 1895).—Owing to the differences observed in the angles between different faces of the same forms, there has been some doubt whether this mineral is rhombic or oblique; these differences are, however, quite irregular, and the author considers the crystals as rhombic. He gives the forms: $c(001)$, $t(113)$, $s(223)$, $r(111)$, $v(774)$, $w(221)$, $m(110)$, $i(012)$, $k(023)$, $e(011)$, $a(010)$, $x(201)$.

Calculated from $mm = 85° 9'$ and $cx = 71° 53'$:—

$$a : b : c = 0{\cdot}91874 : 1 : 1{\cdot}40407.$$

Kokscharov deduces from the measurements of all authors:—

$$a : b : c = 0{\cdot}91753 : 1 : 1{\cdot}41322.$$

The habit of the crystals is as usual prismatic parallel to the brachydiagonal. The brachydomes and brachypinacoid are strongly striated parallel to their intersections. There is no sign of twinning, and the crystals are optically uniform throughout. The optical characters agree with rhombic symmetry. All the Leadhills crystals have been considered as rhombic, while those from Rezbanya and Beresovsk are considered, by Schrauf and Eremyeev respectively, to be oblique. L. J. S.

Kamarezite, a new mineral from Kamareza, Laurium. (K. Busz, *Neues Jahrb. Min.* I. 115-119, 1895).—A small specimen of a grass-green mineral in the Bonn Museum was suspected to be a new species, on account of it giving off more water in a closed tube than brochantite, which it some-

what resembled. The mineral shows a crystalline structure, and contains many small cavities filled with needle-shaped crystals. The mean of four partial analyses was :—

CuO	FeO	SO_3	H_2O
51·50	0·69	17·52	30·29

This agrees with $3CuO{\cdot}SO_3{\cdot}8H_2O = SO_4(CuOH)_2 + Cu(OH)_2 + 6H_2O$. The loss of water begins at about 220°, and up to a dull red heat about half the total amount is given off, the colour of the mineral changing to black; at a higher temperature some SO_3, as well as more water, is expelled. Spec. gr. = 3·98: H = 3. Decrepitates when heated. Insoluble in water; soluble in acids and ammonia.

Crystals are too small for goniometric measurement; under the microscope they are seen to be needles, probably orthorhombic, tabular parallel to what is taken as $b(010)$, and elongated and striated in the direction of the c axis. Perpendicular to the plate and parallel to the striations is a perfect cleavage, $a(100)$. The needles are terminated by macrodomes $c(101)$ and $d(201)$, with angles, measured under the microscope, $ac = 60°$, $ad = 31°$; these give $a : c = 1 : 0{\cdot}601$. Perpendicular to a is a bisectrix, with a large optic angle, the plane of the optic axes being parallel to b.

L. J. S.

Pyrrhotite. (K. Busz, *Neues Jahrb. Min.* 1895, I. 124-127).—Small steel-blue, tabular crystals on calcite from Andreasberg showed a low pyramid $t(221)$ with $m(2\bar{1}\bar{1})$ and $o(111)$. The basal plane was always a little curved, and the pyramid horizontally striated, the prism being bright and smooth. Taking $a : c = 1 : 1{\cdot}65022$, as determined by Seligmann on crystals from the Cyclopean Islands, to be the most accurate and reliable :—

	Calculated.	Measured.	Limits.
mt	64° 32′	64° 46′	64° 38′ — 64° 55′
tt	24° 50′	24° 32′	24° 17′ — 24° 40′

Nearly all measurements made hitherto on pyrrhotite have been only approximate, those by G. Rose for zz varying from 126° 49′ to 127° 25′ on different crystals; these give $a : c = 1 : 1{\cdot}74015$ and $1 : 1{\cdot}65376$ respectively, the latter being near Seligmann's determination. The recorded forms are: $o(111)$, $a(2\bar{1}\bar{1})$, $b(10\bar{1})$, $t(211)$, $s(110)$, $z(100)$, $u(5\bar{1}\bar{1})$, $w(7\bar{2}\bar{2})$, $y(16, \bar{5}, \bar{5})$, $v(52\bar{1})$, (741).

A table of calculated angles is given in the paper.

Streng measured the angles 61° and 24° 4′ from pyramids to the prism

on crystals from Chañarcillo and Kongsberg respectively. These pyramids give simpler indices when referred to the second order :—

	Calculated.	Measured.
$b : 321$	61° 11′	60° – 62°
$321 : 312$	27° 53′	27° 30′ – 29° 20′
$b : 31\bar{1}$	24° 26′	23° 48′ – 24° 23′

D'Achiardi measured on crystals from Bottino (Tuscany) an angle of about 10° from a low pyramid to the basal plane: $c : 343 = 10°\ 47'$ calculated. L. J. S.

Baddeleyite from Brazil (E. Hussak, *Tsch. Min. Mitth.*, XIV. 395-406, 1895. Two Plates).—The present paper gives a more complete account of the mineral than when it was first described by the author under the name brazilite (*Neues Jahrb. Min.* II. 141, 1892). The mineral occurs in the iron mine of Jacupiranga, S. Paulo, as an accessory constituent in decomposed magnetite-pyroxenite (jacupirangite), and also rarely in the limestone contact with this rock. The crystals are tabular parallel to the orthopinacoid, and are mostly 2 – 3 mm. (the largest 5 mm.) across. The colour is usually brownish, but according to the amount of iron present, varies from colourless and transparent to black and opaque. The parameters are now given as :—

$$a : b : c = 0{\cdot}9871 : 1 : 0{\cdot}5114\ ;\ \beta = 98°\ 45\tfrac{1}{2}' :$$

these being derived from the measured angles, $am = 44°17\frac{1}{2}'$; $ac = 81°\ 14\frac{1}{2}'$; $cr = 29°\ 4\frac{1}{4}'$. The forms present are: $a(100)$, $b(010)$, $c(001)$, $m(110)$, $k(120)$, $l(230)$, $p(221)$, $n(\bar{1}\bar{1}1)$, $t(101)$, $r(\bar{1}01)$, $s(203)$, $o(\bar{2}01)$, $x(201)$ only as twin plane, $d(021)$; to these must be added $(\bar{2}21)$ $(= n(\bar{1}11)$ of Fletcher). To convert these to agree with the parameters as chosen by Fletcher (*Min. Mag.* X. 148) the last index must be doubled. Among the many hundred crystals examined only three were apparently simple crystals, and even these on closer inspection showed twin lamellæ. As stated in the original description, there are three twin laws : (1), $a(100)$ is the most frequent, there being both simple and polysynthetic twins; the twinning of the Ceylon crystal is after this law ; (2), m (110), as contact, penetrating and polysynthetic twins ; (3), $x(201)$, contact and penetrating. Twinning on all these laws may occur in the same crystal, the polysynthetic a and m twins being very frequent.

Zonal structure in the crystals is common. The specific gravity was originally given as 5·006, it being then remarked that this was probably

too low, owing to enclosures of apatite needles, and to a coating of limonite on the surface of the crystals: a more recent determination gave 5·5 (sp. gr. of the Ceylon crystal = 6·025). The cleavage is given as $c(001)$, fairly perfect, and b and m less perfect, the latter being, however, a plane of separation due to the polysynthetic twinning (*cf.* Fletcher). The optical characters are the same as those given by Fletcher: as the first mean line is nearly perpendicular to the c cleavage, the optic picture is seen through a cleavage flake. The angle between the first mean line and the vertical crystallographic axis is given as 11° 8′ 18″, in the obtuse angle β. Prof. C. W. Blomstrand's analyses of the mineral (*Neues Jahrb. Min.* I. 89, 1893) gave :—

ZrO_2	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Alkalies	Loss
96·52	0·70	0·43	0·41	0·55	0·10	0·42	0·89 = 99·52

The associated minerals, obtained by washing the decomposed pyroxenite, are described. L. J. S.

Constitution of some alumino-silicates (S. J. Thugutt, *Neues Jahrb. Min., Beil. Bd. IX.* 554-624, 1895).—The various minerals treated are those related to the artificial soda-nepheline-hydrate, $4Na_2Al_2Si_2O_8 \cdot 5H_2O$: on digesting this body with dilute potassium carbonate solution at a temperature of about 200°, it is split up into a potassium natrolite, $K_2Al_2Si_3O_{10} \cdot 3H_2O$ and sodium aluminate $Na_2Al_2O_4$; the constitution is therefore represented as $4(2Na_2Al_2Si_3O_{10} \cdot Na_2Al_2O_4) \cdot 15H_2O$. Lemberg has suggested that the members of the sodalite group correspond to this soda-nepheline-hydrate in having a soda salt in place of the water, and this is confirmed by the manner in which they are split up by potassium carbonate solution. Sodalite is therefore $8Na_2Al_2Si_3O_{10} \cdot 4Na_2Al_2O_4 \cdot 8NaCl$, while in nosean and ultramarine NaCl is replaced by Na_2SO_4 and Na_2S_2 respectively. Owing to the somewhat different behaviour of artificial and various natural specimens of sodalite, when digested with calcium chloride solution, three metameric varieties of this mineral are distinguished. When fused soda-nepheline-hydrate is quickly cooled soda-anorthite is produced, this in microscopic sections shows twin lamellæ and an extinction of about 36°; its constitution is represented by $Na_2Al_2Si_3O_{10} \cdot Na_2Al_2O_4$. Kaliophilite ($K_2Al_2Si_2O_8 = 2K_2Al_2Si_3O_{10} \cdot K_2Al_2O_4$) on digestion with potassium carbonate solution yields a potash mica and free caustic potash: as potash mica has the same empirical formula as this body, it has probably the same constitution, viz. $K_2H_2Al_4Si_6O_{20} \cdot H_2Al_2O$ ($= (K,H)_2Al_2Si_2O_8$). This formula agrees with the more basic potash micas, while in the more acid, as represented by Tschermak's phen-

gite, the group $H_2Al_2O_4$ is omitted. Nepheline, as well as sodalite, is decomposed by long digestion with pure water at an elevated temperature, giving rise to natrolite, sodium aluminate, and some mica or kaolin; for nepheline the constitution is given as $8Na_2Al_2Si_3O_{10}\cdot 4Na_2Al_2O_4\cdot 3K_2Al_2Si_3O_{10}$, which is similar to that of sodalite.

The application of these results is discussed in connection with geological processes and pseudomorphism, especially as regards the alteration of nepheline: from the formula above given for this mineral, it is seen that natrolite, hydrargillite or diaspore, and mica in various combinations could be derived. Hydronephelite is considered to be a mixture of natrolite and hydrargillite, these minerals being derived respectively from the first two groups given in the nepheline formula. L. J. S.

Classification of Ore Deposits (J. H. L. Vogt, *Zeits. f. prakt. Geologie*, 381-399, 1894).—Ore deposits have been variously classified according to (1), chemical and mineralogical composition; (2), outward form; (3), mode of origin, the last being of most importance from a scientific point of view. In the present paper are treated the ores which have originated by magmatic differentiation processes (*cf. Abst.* XI. 38); they are grouped as follows:—

I. *Oxide separations.*

a. Separation of chrome iron ore in peridotites.

b. Of ilmenite and titaniferous magnetite in gabbros, nepheline-syenites, &c.

c. Possibly of iron ores (without titanium) in granites, &c.

II. *Sulphide separations.*

a. Separation (?) of copper sulphides in peridotites, *e.g.* in Tuscany, N. Norway, &c.

b. Of nickel-bearing pyrrhotite in gabbros, &c.

III. *Metallic separations.*

a. Separation of platinum metals in peridotites.

b. Of nickel-iron in various basic rocks.

Under I. *a*, numerous analyses of peridotites are quoted, and it is shown that they contain on an average 0·20 – 0·35 per cent. of Cr_2O_3, which exists as picotite, chromite, and to a smaller extent is present in various silicates; ilmenite, apatite, etc., are exceptional in such rocks. A typical example of chromite deposits, separated by differentiation processes in peridotites, is that of Hestmandö-Feld (N. Norway). The rock here con-

sists mainly of olivine and enstatite, the relative proportions of the two minerals being very variable; picotite and chromite occur, and as these increase, the rock passes through chromite-saxonite and -dunite, into pure chromite, such concentrations occurring in the interior of the masses. In the several masses of serpentine of Norway (*e.g.* Röros) a greater or less concentration of chromite is found. In both the gabbros, &c., and in the peridotites it is noticed that both the oxide and sulphide types of separation occur. L. J. S.

Mineralogical and Chemical Composition of the Dune-sands of Holland (J. W. Retgers, *Neues Jahrb. Min.* I. 16-74, 1895). It is usual to suppose that easily cleavable and decomposable minerals do not occur in sands; such is, however, not the case, as they are found in grains quite as large as those of the more resisting minerals. Sea sands and dune sands are compared, and the action of the wind and sand blasts is pointed out. The grains of dune-sand are only rarely less than a minimum size of ¼ mm. diam., and there seems to be some relation between the size of the grains and the force of the wind. The minerals found in the dune-sands of Holland are, in order of frequency, quartz, garnet, augite, hornblende, tourmaline, epidote, staurolite, rutile, zircon, magnetite, ilmenite, orthoclase, calcite, apatite, and, less frequently, plagioclase, microcline, cordierite, sphene, sillimanite, olivine, kyanite, corundum and spinel. Some of the grains show crystal faces; especially zircon, and less often spinel, magnetite and garnet. Owing to the fact that the density of minerals is subject to variation (due to isomorphous replacement and to enclosures) it is not easy to separate the individual minerals by means of heavy solutions and fused salts. The minerals were therefore separated into the following groups:—

Density.		Per cent.
2·5—2·6	Quartz-orthoclase group	2·5
2·6—2·7	Pure quartz ,,	85·0
2·7—3·0	Quartz-calcite ,,	7·5
3·0—3·3	Amphibole ,,	1·5
3·3—3·6	Pyroxene ,,	1·0
3·6—4·2	Garnet ,,	2·4
4·2—4·5	Rutile ,,	0·05
4·5—4·8	Zircon ,,	
4·8—5·2	Iron ore ,,	0·05

The heavy solutions used were Sonstadt's (Thoulet's), methylene iodide, in which is dissolved iodine and iodoform (specific gravity 3·6—3·65), and fused silver- and thallium-nitrate (*cf. Abstr.* Vol. XI. p. 44). Under the microscope the grains were examined, whole and crushed, in liquids of varying refractive indices. The optical characters, microchemical reactions, and mode of detection of each mineral are treated at some length, and suggestions added as to their origin. Each of the above groups was also analysed quantitatively. It is probable that if large quantities of the sand could be dealt with, rare elements would be found, as the minerals containing these are characteristic of granites and gneisses. Remarks and suggestions are made as to similar work which might be done with river and sea sands, and its importance in connection with geology and sedimentary rocks. A short review of previous work in this direction is given. L. J. S.

Some Dyke-rocks in the Christiania District.—W. C. Brögger has recently published a valuable instalment of his studies on the eruptive rocks of the Christiania district (*Vid.-Selsk. Skrifter, Math.-Natur. Kl.*, 1894, No. 4) dealing with certain rocks which occur mainly in the form of dykes and minor intrusions. In former memoirs he has shown how the whole of the eruptive rocks of the district may be regarded as derived by successive processes of "differentiation" from one initial magma. He now calculates the composition of that magma from the analyses of the various rock-types derived from it, and finds that the figures so found (I.) agree very closely with those for the type Nordmarkite, which is the most widely developed of the several rocks, (II.) the special chemical characteristic, which runs through the whole group of rocks, being the remarkable richness in soda.

	I.	II.
SiO_2	64·2	63·52
Al_2O_3	17·2	17·32
Fe_2O_3 (FeO, and MnO) ...	3·6	3·63
MgO	0·8	0·78
CaO	2·0	1·35
Na_2O	7·0	6·95
K_2O	4·6	5·31
H_2O, TiO_2, etc.	0·6	1·12
	100·0	100·48

The rocks specially treated in this paper are fine-grained to compact, greenish rocks, usually rich in ægirine. The first type, designated *Grorudite*, is a kind of ægirine-granite-porphyry, with or without conspicuous porphyritic felspars. These felspars are microcline and albite, often in microperthitic intergrowth; other porphyritic elements are ægirine, a peculiar hornblende, etc.; the ground-mass is of potash-felspar and albite, ægirine, and a certain amount of quartz. The microcline has usually the "moiré structure" rather than the familiar cross-hatching. The hornblende is a soda-bearing variety distinct from both barkevicite and arfvedsonite, having an extinction angle ($c\,\gamma$) of 30° to 60°, and a pleochroism formula $\beta > \gamma > \alpha$ (reddish colours): it is here named catoforite. The chemical composition of grorudite, the mean of four examples, is given under column III.:

	III.	IV.	V.	VI.
SiO_2	70·19	64·92	56·58	45·18
TiO_2	0·29	—	—	—
Al_2O_3	11·96	16·30	19·89	23·31
Fe_2O_3	4·94	3·62	3·18	6·11
FeO	1·18	0·84	0·56	—
MnO	0·48	0·40	0·47	—
MgO	0·16	0·22	0·13	1·45
CaO	0·65	1·20	1·10	4·62
Na_2O	5·73	6·62	10·72	11·17
K_2O	4·06	4·98	5·43	5·95
H_2O	0·30	0·50	1·77	1·14
	99·94	99·60	99·83	98·93

it compares closely with the soda-granite with which the grorudite dykes are associated, having, however, more ferric oxide and alumina. Associated dykes consist of an aplite which, on the other hand, is poorer in iron: this and the grorudite are regarded as complementary products of differentiation of the soda-granite-magma.

The next type, named *Sölvsbergite*, is a less acid rock than the preceding, and has little or no quartz; in other respects it is mineralogically very like the grorudite. Structurally it is somewhat different, being rarely porphyritic and approaching some trachytes in its characters. It is a true dyke-rock ("hypabyssal" rock). The corresponding volcanic or surface rock is ægirine-trachyte; the corresponding abyssal or plutonic rock is nordmarkite. A chemical analysis gave the figures under IV.

There is somewhat more ferric oxide and less alumina than in the nordmarkite, to which these dykes belong, the kind of differentiation being thus similar to that evinced by the grorudites. Further, there are associated with the sölvsbergite dykes others of a complementary type (lindöite).

Another type of dyke-rock in the district answers to the *Tinguaite* of Rosenbusch, and is of still more basic composition. In this not only is quartz wanting, but nepheline appears with some abundance. The chemical composition is indicated in column V. This rock is connected with the nepheline-syenite of the district, and stands related to that rock just as the grorudite does to the soda-granite and the sölvsbergite to the nordmarkite. Here, too, are found dykes of complementary composition ("syenite-aplite"). The three types of dyke-rocks specially dealt with in this memoir thus appear as modifications in a definite direction of the various plutonic magmas. Perhaps some clue to the mode of differentiation which produced the partial magmas is furnished by the observation that the individual dykes sometimes grow somewhat richer in ferric oxide and poorer in alumina towards their edge. By going to other districts the author supplements the grorudite-sölvsbergite-tinguaite series by another, more basic type, which he styles *Sussexite*. This is represented by Kemp's rock from Beemerville in New Jersey (analysis VI.), and approximately by other examples. A. H.

Serpentine as an original igneous product.—We have already noted (*Min. Mag.* Vol. X. p. 34) a memoir by E. Weinschenk dealing with the serpentine-rocks of the eastern Central Alps. In that he concluded that these rocks were in every case altered igneous intrusions, having been for the most part rocks rich in non-aluminous pyroxene, now converted into serpentine with the "Gitterstructur." More recently this author has come to very different conclusions concerning the same rocks (*Abhand. k. bayer. Akad. Wiss.* II. Cl. Vol. XVIII. part 3). He still finds the serpentine-rocks incontestably of igneous origin, but he now believes that much of the mineral serpentine in them is original. The least altered type, to which he gives the name *stubachite*, consists essentially of olivine and serpentine with some chrome-spinel, and only locally a considerable amount of diallage. It is a peridotite, only exceptionally graduating into a pyroxenite (diallage-rock). The serpentine is antigorite in flakes, which are often interposed in the olivine with a definite arrangement, namely, in two directions parallel to the brachydome (011) of the latter mineral. The author regards this as an original intergrowth of olivine

and antigorite. In most of the rocks the olivine and (to a less extent) the diallage have been altered, so that original and secondary serpentine together make up most of the mass. The reasons given for regarding the antigorite as an original product from the igneous magma do not seem to be perfectly convincing, but the phenomena described by the author are sufficiently remarkable to deserve careful consideration.

A. H.

A perofskite-magnetite-rock from Brazil.—Aggregates very rich in iron ores, occurring as peculiar facies of basic igneous rocks, have already been described from Brazil by O. A. Derby, the "jacupirangite" type (a magnetite-pyroxenite) being of special interest. More recently E. Hussak has drawn attention to a remarkable mass occurring at Catalao in the state of Goyaz (*Neu. Jahrb. für Min.* 1894, Vol. II. p. 297). It consists essentially of magnetite and perofskite. The former is partly in little crystals 1 to 2 mm. in diameter, partly in irregular patches and veins wedged in between the crystal-grains of perofskite. The latter, making up the greater part of the rock, are about 2 mm. in diameter, and show in a thin slice the usual high refringence and birefringence of the mineral. For the most part, however, the perofskite is decomposed to a dark, reddish-brown earthy substance, which proved to be pure titanic acid (perhaps anatase). A. H.

Mica-Hypersthene-Hornblende-Peridotite from Bengal (T. H. Holland, *Records Geol. Survey of India*, XXVII. p. 142, 1894). Mention is made of previously recorded mica- and mica-hornblende-peridotites, amongst which the scyelite of Caithness is the nearest approach to the present rock from Mánbhúm. According to the essential and primary constituents, in their approximate order of proportion, the rock may be described as an olivine hornblende-biotite-hypersthene-augite-rock; apatite, magnetite, pyrites, pyrrhotite and labradorite also occur. The ophitic plates of biotite, which is the last formed of the primary constituents, often determine the fracture of the rock by their cleavage; a fractured surface showing the usual lustre-mottling. The magnetite and plagioclase are of secondary origin. The sp. gr. of the fresh rock is 3·234. L. J. S.

Phosphatic Mica-Peridotites from Bengal. (T. H. Holland, *Records Geol. Survey of India*, XXVII. p. 129, 1894).—The so-called "mica-traps" occurring as dykes in the coal measures of Lower Gondwana age of various parts of the Bengal coal fields, prove to be ultrabasic rocks,

often with large amounts of apatite (up to 11·4 per cent.) in slender prisms. Other original constituents are olivine and biotite, as well as anthophyllite, augite, and iron ores (magnetite, chromite, ilmenite), which in various proportions give olivine-mica-apatite-rock, mica-olivine-anthophyllite-augite-rock, &c. Secondary minerals are serpentine, magnetite, perofskite, and rhombohedral carbonates (containing magnesium). The structure of the rocks varies from coarse holo-crystalline at the centre of the dykes to compact at the margins. The sp. gr. of the least altered rock is 2·99, being less in the much decomposed yellowish rocks. The anthophyllite appears to be optically negative, and the pleochroism is :—

a = a, straw-yellow.
b = b, claret-red. Absorption, b > c > a.
c = c, gamboge-yellow.

These rocks are somewhat similar to the diamond-bearing peridotite of South Africa, which they also resemble in their mode of occurrence and age. L. J. S.

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